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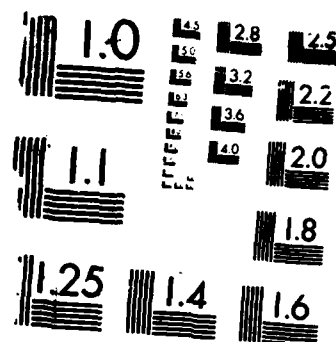
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# INFORMATION BULLETIN

European Science Notes Information Bulletin  
Reports on Current  
European/Middle Eastern Science

Behavioral Sciences	1
Biological Sciences	7
Material Sciences	17
Mathematics	26
Mechanics	28
Ocean Sciences	48
Physics	54
Index of ONRL Publications for 1987	75

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# ESN INFORMATION BULLETIN

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87-02

## Behavioral Sciences

- Research on Internal and External Memory  
Systems Conducted at the Free University  
of Berlin; ..... William D. Crano 1

The work of Wolfgang Schönplug concerned with the principles in controlling the use and choice of external versus internal information is reviewed. The author states that such work is important to the study of human cognitive functioning, and he hopes that the approach exemplified in Schönplug's work will be more widely used.

## Biological Sciences

- 17th Annual Meeting of the Scandinavian  
Society for Immunology; ..... Claire E. Zomzely-Neurath 7

Selected presentations at this conference, held in June 1987 in Uppsala, Sweden, are reviewed. Topics are cell receptors and antigens, B cells and antibodies, genes and gene expression in lymphoid cells, and new immunological methods.

- Biotechnology at Warren Spring Laboratory,  
Stevenage, UK; ..... Claire E. Zomzely-Neurath 13

The work of the Warren Spring Laboratory's Biotechnology Division is reviewed. The discussion focuses on the efforts in downstream processing--in particular, on primary separation and bacterial genetics--and industrial microbiology.

## Material Sciences

- Sixth European Microelectronics  
Conference; (EMC/87) ..... Robert W. Vest 17

The papers presented at this meeting, held in June 1987 at Bourne-mouth, UK, are briefly summarized under the topics of high-density, inter-connection systems, materials in hybrid technology, and surface mount technology.

- Creep and Fracture of Engineering  
Materials and Structures--Third  
International Conference ..... John P. Gudas 19

Selected presentations given at this conference, held in Swansea, UK, are reviewed. Topics under which the papers are reviewed are: mechanisms of creep and fracture, deformation and fracture of particle-strengthened alloys, creep and fracture of steels, damage accumulation and creep crack growth, and remanent life assessment.



A-1

Sialon Ceramics Research at The University of Newcastle-Upon-Tyne ;.....	Louis Cartz	23
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Sialon ceramics are investigated at Newcastle-Upon-Tyne by the group headed by Dr. D.P. Thompson. Nitrogen sialon glasses are shown to be transparent. Methods of overcoming the effects of the glassy grain boundary phase are being investigated.

## Mathematics

Artificial Intelligence and Related Research at Salerno ;.....	Paul Roman	26
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Unusual, broad-based, multidisciplinary work on the fundamental, structural aspects of artificial intelligence research is done at the Department of Theoretical Physics, University of Salerno, Italy. Neural network (cellular automata) analysis is the current focus, but many other aspects of large, complex, interacting systems are also explored. Specific examples are image analysis or mathematical linguistics.

## Mechanics

Joint Meeting of the French and Italian Combustion Societies ;.....	Eugene F. Brown	28
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Selected CFD-related presentations at this meeting, held in June 1987 in Amalfi, Italy, are reviewed. Topics under which the presentations are grouped are: gas turbine combustion, combustion simulation and modeling, industrial applications, and experimental investigations.

US-France Workshop on Turbulent Reactive Flows ;.....	Eugene F. Brown	35
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This joint US-France workshop was held in July 1987 in Rouen, France. Presentations given in the four sessions--structure of turbulent flames, measurements, supersonic combustion, and numerical methods--are reviewed.

Fluid Mechanics Research at the University of Naples ;.....	Eugene F. Brown	42
--	-----------------	----

A wide variety of fluid mechanics researches are being undertaken at the University of Naples including both fundamental and applied work. Close links with the new Italian Center for Aerospace Research is likely to accelerate the development of aerospace-related research at the university.

Fluid Mechanics and Combustion Research at The Polytechnic University of Madrid and The University of Zaragoza ;.....	Eugene F. Brown	45
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Research in fluid dynamics and combustion at these two universities is reviewed. The author states that Spain has only a few centers, such as the ones he reviews, which have well-developed research programs, but he expects that in the next few years there will be a sharp increase in the number of Spanish universities developing high-quality research programs in fluid dynamics.

## Ocean Sciences

- COST-43: Seminar on Operational  
Ocean Station Networks ..... Jerome Williams 48

This fifth COST-43 technical seminar was held in June 1987 at Brest, France. The presentations are summarized and discussed under the headings of COST-43 programs, national and international programs, and evaluation and new developments.

- Air-Sea Interaction Meeting of the  
UK's Royal Meteorological Society ..... Jerome Williams 51

Presentations made at this meeting, held in July 1987 at Southampton University, are reviewed. Topics include bubble clouds, fluxes, fronts and gradients, remote sensing, models, and ice.

## Physics

- A Small French Meeting on  
Optical Communications ..... Paul Roman 54

This article reviews selected topics presented at the "Telemat 87--Horizons de l'Optique" conference, held at Marseille in June 1987. The general background of the conference is described, and optical telecommunication, optoelectronic materials and devices, and integrated optics, as well as the possible role of optics in computers, is given special attention.

## News and Notes

- Report of Future Sensor Needs of UK Bio-  
technology-Based Industries is Now Available ..... C.J. Fox 57
- Materials Research in Göteborg, Sweden ..... Louis Cartz 57
- Meeting on Composite Materials in  
Sweden, March (1988) ..... Louis Cartz 59
- Mechanical Testing of Engineering Ceramics  
at High Temperatures ..... Louis Cartz 59
- Hydraulics and Fluid Mechanics Research at  
Ecole Polytechnique Fédéral de Lausanne ..... Eugene F. Brown 59
- Oceanography: Institut Français de Recherche  
Pour l'Exploitation des Mers (IFREMER) ..... Jerome Williams 61
- New International Advanced Multidisciplinary  
Theoretical Study-Institute Announced ..... Paul Roman 63
- Structural Effects in Amorphous Ferromagnets--  
An ONRL-Supported Conference Session ..... Paul Roman 63
- ONRL-London has Sponsored a Conference  
Session on Unusual Applications of  
Advanced Molecular Spectroscopy ..... Paul Roman 64
- An International Optics Exhibition in Madrid ..... Paul Roman 65
- UK Establishes Joint Committee to Support  
Development in Superconductivity ..... C.J. Fox 66
- ONRL Cosponsored Conferences ..... 67

ONRL Reports .....	67
Behavioral Sciences	
Biological Sciences	
Material Sciences	
Mechanics	
Overseas Travelers .....	68
Astronomy	
Chemistry	
Electronics	
Oceanography	
Physics	
Reports on European Science and Technology	
From Other Commands .....	71
Chemistry	
Life Sciences	
Material Sciences	
Mechanics	
Physics	
Technology Roundup--Italy .....	73
Science Newsbriefs .....	74
Military Applications Summary Bulletins .....	74
Index of ONRL Publications for 1987 .....	75

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## Behavioral Sciences

### RESEARCH ON INTERNAL AND EXTERNAL MEMORY SYSTEMS CONDUCTED AT THE FREE UNIVERSITY OF BERLIN

*by William Crano. Dr. Crano is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Texas A&M University, where he is a Professor of Psychology.*

The principles that govern the manner in which people store information in memory is a continuing concern of experimental psychology. Now, social psychologists, too, have become concerned with the more socially oriented memory processes--e.g., person memory (cf. Hastie, 1977; Hastie and Carlson, 1980; Hastie and Kumar, 1979). Most current US research on memory is focused on what might be called "internal" information storage. (For a noteworthy exception see Wegner's work on transactive memory: Wegner, 1985; Wegner, Giuliano, and Hertel, 1985.) That is, we have directed our research attention to the study of tactics that people use when encoding information into long-term memory, or when retrieving information from memory in order to apply the previously stored information.

There is a whole range of memory phenomena, however, that are not addressed in contemporary mainstream memory research in psychology. These phenomena have to do with the *external storage* of information, a ubiquitous feature of modern life. Since the invention of typography, external storage devices (e.g., books, lab notes, magnetic tapes, diskettes, etc.) have exceeded human memory in terms of capacity, stability, and at times, speed of encoding. Yet, almost no formal research has been directed to the principles involved (if any) in controlling the use and choice of external versus internal information storage. Wolfgang Schönpluf (Free University, West Berlin) has attempted an ambitious experimental attack on this problem. The results of his research series on the factors that influence the trade-off criteria that mediate the choice of internal representation or external storage of information is the focus of this report.

### Two Nonindependent Systems of Mental Representation

Broadly, people can store information in two ways--in internal memory, and through external devices, such as notes, books, etc. The advantages and disadvantages of these mechanisms are very different. Information retrieval from internal memory is practically automatic. It is fast, tailored to the needs and context within which the recall occurs, and generally consistent with the intentions of the information retriever. However, internal storage capacity is limited, and its efficiency can be degraded by a host of contextual distractors.

External storage devices are practically limitless in terms of capacity, and they can be extremely fast. However, they are nonreactive (or nonaccommodative)--i.e., they do not adjust to the context or to the needs of the individual. In addition, in order for them to be useful, externally stored data must be represented, or tagged, in internal memory; the individual must know that the requisite information is stored externally, where it is stored, how it is organized, and how to access it. Thus, the utility of an external storage device is in a very major respect dependent upon the quality of its representation in internal memory.

Research on metamemory--the manner in which people remember *how* they remember, the strategies they use to store or retrieve information--could profit from considerations focused on the issue of internal/external storage of information (cf. Flavell and Wellman, 1977). Almost all research on metamemory is concerned ultimately with internal representations. Clearly, however, if external storage is established as an important feature of human memory, then the metamemory rules governing its utilization are worthy of detailed consideration. As Schönpluf has observed, "So long as mainstream memory psychology does not deal systematically with external storage, it misses substantial pragmatic, ecological, and evolutionary aspects of the memory function."

Considerable research points indirectly to the importance of understanding external memory. Many experiments on problem solving, arithmetic, design tasks, etc. have shown that keeping notes or consulting a list of decision rules increases the amount of information available to the problem-solver, and subsequently enhances performance. In psychology, however, the only research directly focused on external encoding and retrieval has been undertaken in the study of the effects of note-taking during lectures (e.g., Barnett, DiVesta, and Rogozinski, 1981). While offering

some useful information, the literature of this area is uninformative with respect to the more general issue of the conditions under which internal memory or an external device will be the preferred information storage mechanism.

### Two Preliminary Studies

In the preliminary investigation of this issue, Schönplüg (1986) performed a simple experiment in which subjects were asked to imagine that they had been stranded on a desert island for 12 years, cut off from all information of the current world of 1999. They were to be exposed to a series of texts which described current conditions, and they were to be prepared to produce a reproduction of the texts after the entire list (of 27 texts) had been presented.

They were given the option of memorizing the information presented on a given text, or memorizing the text reference, which would allow for its retrieval from the computer in which it was stored. The texts varied in terms of difficulty: more difficult texts contained more words and more information. Reference difficulty, too, was systematically manipulated. The principal measures of the study were concerned with subjects' ratings of the difficulty of the texts and their references (forms of manipulation checks), and their intention to memorize one or the other or both of these two data components. Actual memory performance was not a critical feature in the study, which was concerned primarily with the subjective trade-off *decision* between text and reference learning, and the effect of difficulty on this decision.

Interestingly, a substantial and statistically significant preference favoring text learning over external storage was found in the study. When a difficult text was encountered, subjects attempted to learn it and its reference. With easy texts, only the text was learned, its reference neglected. The difficulty level of the reference was of only secondary relevance. In many ways, these results make good sense. Clearly, if one is to use the reference, he or she must know what it contains (i.e., remember at least something of the text). Thus, reference learning (which entails the use of an external storage mechanism) of necessity involves text learning (internal storage). As such, it often can involve more cognitive effort than internal representation, and it is thus employed only when text memorizing is of sufficient difficulty to practically force the issue.

Of course, this study far from settles the question. There are aspects of

the findings that might be questioned: was the magnitude of the relative variations in information complexity contained in texts and references sufficient to produce an effect? what was the influence of other potentially critical variables? etc. Schönplüg recognized the fact that there was still much to be learned on this issue, and planned a series of experiments designed further to elucidate the factors that influence people's choice of internal and external storage mechanisms.

Before he began, however, Muthig and Piekara (1984) reported on research that produced results certain to provoke puzzlement among those who, like Schönplüg, believed that principles of cognitive economics would govern the manner in which people would store information. In their study, Muthig and Piekara told their research subjects to assume that they were to write a report on living conditions for humans on a fictitious planet about to be populated. Sixty statements were presented regarding various aspects of life on the planet, and they were to base their report on this information. Half the statements were relevant for the task, the others irrelevant. The statements varied in their generality-specificity and in their linguistic complexity (cf. Kintsch et al., 1975).

Subjects were allowed either to take notes on the texts, or to request printed copies of any of the 60 statements. Analysis disclosed that the number of notes taken was almost exactly equal to number of copies requested, and both of these measures were almost completely determined by the relevance of the information for the task at hand. Previous research (Hillis & Crano, 1973) had already demonstrated the importance of information relevance (or utility) in determining subjects' self-exposure to information, and Muthig and Piekara's results replicate these earlier findings. In addition, however, their data suggest that specificity, ratings of text difficulty, and linguistic complexity of information were of but minor influence on subjects' preferences for the use of internal or external storage mechanisms.

### Text Length, Relevance, and Specificity

These results did not strike Schönplüg as definitive or as completely reasonable--probably because they proved so contrary to his theoretical expectations. In attempting to rationalize the developing theory concerned with the trade-off between internal and external storage mechanisms with the findings of

Muthig and Piekara, he proposed the following line of logic:

- Text complexity adds to the demands on internal memory, and thus will foster a shift from internal to external storage
- However, if externally stored information must be represented internally--
- Then external storage will be effective only if the internal representation of the (externally stored) data is *sufficiently reduced* to prove advantageous to the human information processor (cf. van Dijk, 1980)
- Therefore, external storage will be undertaken only with complex items.

With this set of ideas in mind, Schönpflug began an investigative series that was to reinforce the adage, "When the data get in the way of a good theory, try again."

The central task of the subjects in this study was similar to that used by Muthig and Piekara. Subjects were told that they were going to have to write a paper on the issue of a mass immigration to a newly discovered planet, Theleos. The paper was to list all the positive and negative features of life on the planet. In their instructions, subjects were told:

Theleos is a newly discovered planet. First projects of interplanetary transportation, of colonization and exploitation have been fairly successful. The initial experiences have promoted the idea of turning the planet Theleos into an alternative homeland for terrestrials, and thereby reduce the overpopulation of the earth. [We now have] to make a decision whether to launch a program for mass emigration. The material to be considered in the report to be written...is kept in archives, and a search through the archives is needed to find all relevant material. However, there is no systematic documentation of the relevant material available; therefore, a larger stock of material has to be searched through which also contains irrelevant pieces of information.

A total of 108 texts were presented via computer terminal. They varied in length, relevance, and degree of specification. In addition, presentation time was systematically varied: some subjects could inspect a text for as long as they liked; for others, the text disappeared from the screen after 20 seconds. A final variable manipulated the costs for external storage: In one condition of the design, subjects needed only to press the

"P" key of the computer keyboard to receive a print-out of the displayed text; other subjects were forced into an extended (70 second) dialogue with the computer before a given text would be printed.

The results of this study were much closer to expectations than those of earlier experiments. There were many interesting results discovered in the research, but the most important of these were that (1) subjects were more likely to make use of external storage devices when the text was relevant, and (2) this tendency was exaggerated when the text was long or specific. As might be expected, exposure time to the texts increased as costs for printing increased; people were more likely to memorize a text (i.e., to use internal storage) as external storage costs increased. Figure 1 presents a good summary of the major findings of the study.

One apparently anomalous result reported by Schönpflug concerned the failure to observe an increase in use of external storage under conditions of limited exposure time. It seems natural that subjects who did not have sufficient time to memorize a relevant text would be more likely to resort to the printer than those who could study the text at their leisure. However, this differential tendency was not apparent. I believe that the difference did not occur because all subjects printed most relevant texts regardless of temporal constraints. As a

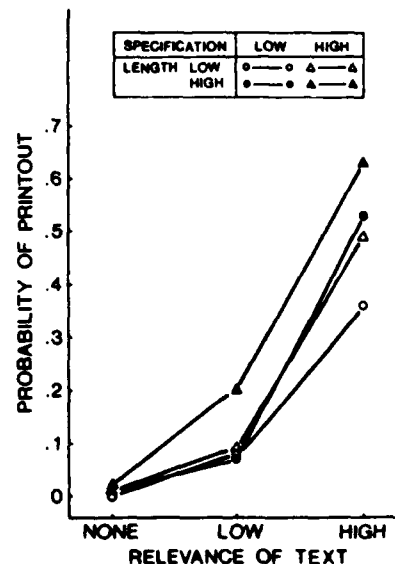


Figure 1. Probability print-out (storage) as a function of text length, relevance, and specificity.

consequence, no differential tendencies to store data between the high and low processing-time groups were evident. External storage had reached a psychological ceiling under some of the experimental conditions. The data of Figure 1 support this interpretation, and help to make sense of an otherwise puzzling lack of difference.

#### Enhancing Ecological Validity

A second study was performed to lend greater reality to the information search/trade-off decision task. In this experiment, text material was presented hierarchically. The first level of the text hierarchy presented in a very few words the theme of the information that was contained within the remaining members of the hierarchy. So, for example, the first entry might read, "The weather conditions on Theleos." The second level of the text hierarchy elaborated on this theme: "Theleos has a regular day-night rhythm, accompanied by equally regular variations in temperature. Wind and cloud formation with precipitation may be observed." The third and fourth levels were even more detailed. Mean numbers of words per level were 4 on level 1 (range: 2-8 words), 18 for level 2 (range: 9-49 words), 27 on level 3 (range: 16-52 words), and 50 on level 4 (range: 26-95 words).

The procedure of the experiment was much like that of the first of Schönpflug's studies, except that a "no relevance" text condition was added to the low and high relevance text presentations, and no exposure time variation was included--subjects could view materials for as long as they liked. In general, the results of this study confirmed earlier findings. Analysis of the data demonstrated that:

- Relevance of text information was a major determinant of subjects' use of external storage
- Greater relevance resulted in more frequent storage
- Costs for storage had a significant impact: the higher the costs for printing, the lower the probability of printouts (given material of equal relevance).

The text-hierarchy variation also made for interesting effects. Basically, subjects were always exposed first to the lowest level of each of the text hierarchies, and from there could choose to enter more deeply into the material by exposing themselves to successively higher steps in the hierarchy. In some cases, of course, the first-level information was completely irrelevant to the task at

hand, and this signified that the (more detailed) information that followed within that hierarchy also was irrelevant. In this event, further exposure within the hierarchy almost never occurred. However, as subjects entered deeper into the *relevant* hierarchies, exposure time increased, as did the likelihood that the information would be printed. At each successive level within the relevant hierarchies, printout (i.e., external storage) probabilities increased.

#### Recall and Dissociation, Experts and Assistants

A central tenet in all of the work discussed to this point is that the efficiency of externally stored material is dependent upon the quality of its internal representation. When external information becomes dissociated from its internal representation (by, for example forgetting), then the quality of recall is degraded. In the third and final experiment of this series, Schönpflug attempted to construct an analogy in which maximal dissociation occurs between internal and externally stored information. He did this by studying two subjects in tandem in each experimental session: the job of the first was exactly the same as that of the subjects in the second experiment--to examine hierarchical information, and decide which to store and which to memorize. The general instructions and overview of the task as presented to the subject were exactly the same as those presented subjects in the earlier study: He was to read information about a soon-to-be inhabited planet, Theleos, and to write a report regarding the pros and cons of this venture. To facilitate this task, the subject could either memorize the information that was presented (as in Study 2, the information was presented in a hierarchical fashion) or print out relevant data. Let us call this individual the *expert*.

The second subject in each group was told that he was to act as an assistant to the expert. The assistant's task was to select and print material that would be considered by the expert in developing his report. The assistant himself was not to write the report, and he could not communicate directly with the expert. Thus, the assistant was an agent of storage, but not of retrieval. This setup is interesting because it creates an analogy to a situation within the individual in which internally and externally stored information is dissociated. Clearly, the expert could not have an internal representation of the information stored for him by the assistant. As such, there is maximal dissociation between the two forms of data. Of course, the choices



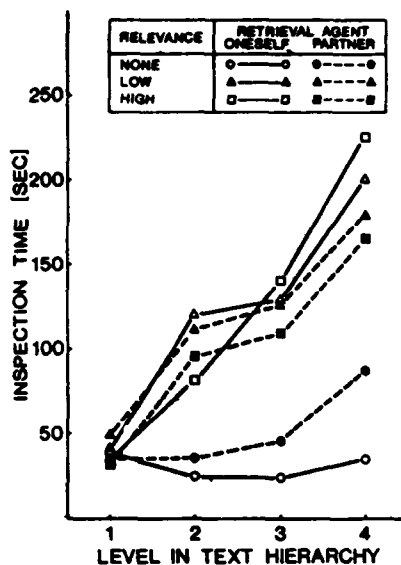


Figure 2. Mean exposure times as a function of text relevance, hierarchy level, and retrieval role.

of the assistant were never really made available to the expert in this study. The point of the experiment was to investigate similarities and differences in patterns of information exposure and storage between individuals working in the different roles.

The methodology of the study differed only slightly from the second experiment. The same hierarchically arranged text material was used, as before. There was no time limit on exposure to information. The role of "assistant" constituted the significant addition to the research operations.

The results on exposure time are presented in Figure 2. As shown, there was a clear tendency for lengthier exposure on the part of the experts--especially if the text was of high relevance. In addition, there was a general tendency for relevant information to be inspected for longer periods as the subject climbed the informational hierarchy. This tendency was greater for experts than for assistants.

Figure 3, which is concerned with the probability that a text would be printed (or stored), provides some explanation for this finding. As shown, the assistants were more likely than experts to print texts of either high or low relevance. At the third and fourth levels of the text hierarchy, for example, Figure 3 indicates that the assistants were apt to press the print button much more readily than the ex-

perts. As such, there was less need for them to spend much time exposing themselves to the information. Having decided that a given hierarchy was relevant, the assistant needed merely to proceed through it to the third or fourth level, and print the information. The expert, on the other hand, had to form an internal representation of the printed material--no matter what its position in the hierarchy--in order to be able later to use the stored information efficiently. Finally, as shown in Figure 3, there was a significant difference between experts and assistants in terms of likelihood of external storage: the experts were less likely than the assistants to store information.

These results are interesting because they indicate that relevance and complexity of information affect the behavior of people who are encoding information for another in much the same ways that they affect people encoding material for their own use. To be sure, the print-out (storage) rate of the assistants was considerably greater than that shown by the experts; this finding suggests that internal processes were used by experts to replace external storage. The difference between assistants and experts decreased at higher levels of relevance. This, too, is as it should be: at all levels of relevance, the assistant would be more likely to store information, and this tendency would grow at higher levels of the hierarchy. The expert's reaction,

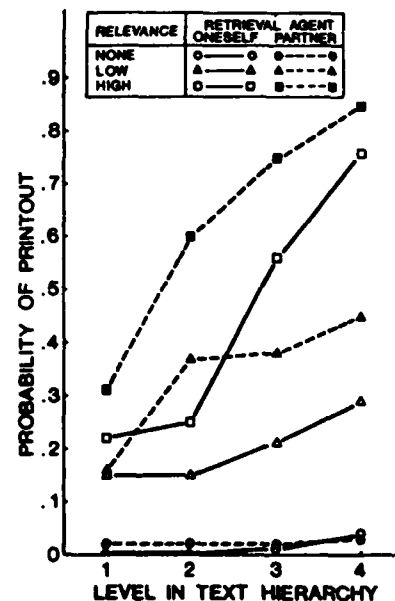


Figure 3. Probability of printout (storage) as a function of text relevance, hierarchy level, and retrieval role.

however, might be expected to be somewhat less linear. He well might store the high-level information externally, but for information at the low level of the hierarchy, he is perhaps more likely to use internal storage and disregard the printer.

Interestingly, the assistants did not store everything available, nor even all highly relevant information. They, like the experts, recognized that processing masses of information was not efficient, and apparently were guided by concerns for parsimony and information processing efficiency. Most likely to be omitted was irrelevant information, and then information that appeared to replicate data stored earlier, even if the information to be omitted was highly relevant.

#### Some Final Observations

The present series of studies represent an initial, exploratory attempt to understand more about the processes that govern the external storage of information. In and of itself, the fact that there is so little information about these processes, relative to that involving internal (memory) storage, commends this research. There is still much to be learned--the present research series merely scratches the surface. For example, it would have been nice to have had some outcome measures in these experiments (e.g., quality of the paper written on the basis of the information encoded), perhaps some measures of individual differences in choice and operation of memory systems, etc. However, it would be misguided to be too critical of this work. It is an initial approach to the study of an important issue, and should be read as such.

Most directly, the importance of this research resides in the information it provides about the operation of external storage mechanisms, and about the trade-off criteria that people employ when deciding between internal representation and external storage of information. However, since external information storage is, of necessity, accompanied by an internal representational tag to the external data store, it cannot be viewed as independent of the study of learning and retention. As such, investigations of indirect storage mechanisms can provide important insights into internal memory processes. As an additional advantage, studies of this type offer a new methodology that profitably may be used by researchers in human memory. The methods employed in the study of external mechanisms may allow us to infer the operation of internal memory processes by observation of overt behaviors, which

share common functional features with the internal memory system. In addition, the study of external storage systems makes available experimental manipulations that are not possible in traditional memory research.

The study of the external storage of internally represented information offers a host of methodological and theoretical advantages to the scientist committed to the study of human cognitive functioning. It is my hope that the general approach exemplified in Professor Schönpflug's work will be more widely adopted and employed. We are only at the beginning of a long road to understanding the human memory. The study of the trade-off criteria that people use in employing internal or external information storage may greatly facilitate our voyage.

#### References

- Barnett, J. E., F.J. DiVesta, and J.T. Rogozinski, "What is learned in note taking?" *Journal of Educational Psychology*, 73 (1981), 181-192.
- Flavell, J. H., and H.M. Wellman, "Metamemory," *Perspectives on the Development of Memory and Cognition*, eds. R.V. Kail and J.W. Hagen (Hillsdale, NJ: Erlbaum 1977).
- Hastie, R. "Schematic principles on human memory," *Social cognition: The Ontario symposium on personality and social psychology*, eds. T.E. Higgins, C. Herman, and M.P. Zanna, 1, (Hillsdale, NJ: Erlbaum 1977).
- Hastie, R., and D.E. Carlston, "Theoretical issues in person memory," *Person memory: The cognitive basis of social perception*, eds. R. Hastie, T. Ostrom, E.B. Ebbesen, R.S. Wyer, D.L. Hamilton, and D.E. Carlston (Hillsdale, NJ: Erlbaum 1980).
- Hastie, R., and P.A. Kumar, "Person memory: Personality traits as organizing principles in memory for behaviors," *Journal of Personality and Social Psychology*, 37 (1979), 25-37.
- Hillis, J.W., and W.D. Crano, "Additive effects of utility and attitudinal supportiveness in selection of information," *Journal of Social Psychology*, 89 (1973), 257-269.
- Kintsch, W., E. Kozminsky, W.J. Streby, G. McKoon, and J.M. Keenan, "Comprehension and recall of text as a function of content variables," *Journal of Verbal Learning and Verbal Behavior*, 14 (1975), 196-214.
- Muthig, K.P., and F.H. Piekara, "Externes Speichern von Textinformationen in Abhängigkeit von Textkomplexität und Handlungskontext," *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, 16 (1984), 206-219.

- Schönplflug W. "Internal representation of externally stored information," *Man-Computer Interaction Research*, eds. F. Klix, and H. Wandke (Amsterdam: North Holland-Elsevier Science Publishers, 1986).
- van Dijk, T.A., *Macrostructures* (Hillsdale, NJ: Erlbaum, 1980).
- Wegner, D.M. "Transactive memory: A contemporary analysis of the group mind," *Theories of group behavior*, eds. B. Mullen, and G.R. Goethals (New York: Springer-Verlag, 1985).
- Wegner, D.M., T. Giuliano, and P. Hertel, "Cognitive interdependence in close relationships," *Compatible and incompatible relationships*, ed. W.J. Ickes (New York: Springer-Verlag, 1985).

8/22/87

## Biological Sciences

### 17th ANNUAL MEETING OF THE SCANDINAVIAN SOCIETY FOR IMMUNOLOGY

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1988 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

#### Introduction

Symposia, workshops, poster sessions, summer school, and exhibitions were features of the 17th Annual Meeting of the Scandinavian Society for Immunology, which was held at Uppsala University, Uppsala, Sweden, from 1 through 6 June 1987. The largest number of the several hundred participants were from the Scandinavian countries (Norway, Finland, Denmark, Iceland, and Sweden) with Swedish scientists in the majority. However, there were also attendees from other West European countries such as Switzerland, West Germany, and France. In addition, the UK, US, Canada, Japan, Australia, Argentina, Ethiopia, Israel and Poland were also represented.

The first day of the meeting was devoted to a special symposium entitled "Neuromodulation of Immunity." The topics addressed in three symposia were:

- T-cell receptors and T-cell function
- Immunology of infectious disease
- Immunology of parasitic disease.

In addition, there were 14 workshop sessions on:

- Immunodeficiencies-AIDS
- Immunology of infectious disease
- Transplantation immunology
- Cell surface receptors and antigens
- Regulation and function of natural killer (NK)-cells
- B-cells and antibodies
- Autoimmune disease
- T-cell interactions
- Genes and gene expression in lymphoid cells
- New immunological methods
- Vaccines and antigen presentation
- Lymphokines, growth factors, and complement
- Role of MHC (major histocompatibility complex) and MHC-associated gene expression in tumors
- Neuromodulation of immunity.

Three to four workshop sessions took place concurrently during the period of the meeting. The summer school which was scheduled to follow the conference was a 2-day teaching session covering the topic of the expression of oncogenes and regulation of growth and differentiation in normal and malignant lymphoid cells.

A wide range of subjects in the area of immunology research as well as many excellent presentations were covered during this conference. Sweden, in particular, has been and still is very strong in immunology research and this was manifested by the high level of research presentations. Since it is not possible to report on all the talks given at this meeting, only summaries of selected papers can be presented in this relatively short report.

#### Cell Receptors and Antigens

Studies on the induction of leukocyte aggregation by antibodies to large sialoglycoprotein were reported by B. Axelsson (Department of Immunology, University of Stockholm, Sweden). Monoclonal antibodies reacting with large sialoglycoprotein (LSGP, molecular weight of 120 kDa) were found to produce aggregation of human leukocytes. Whole immunoglobulin (IgG) as well as Fab-fragments of the antibodies induced aggregation at doses of 10 nanograms/ml, well below the saturation dose. Aggregation was visible

after 3 hours and reached a maximum after about 6 hours. In T-cell cultures, the majority of cells participated in aggregate formation whereas in B cell cultures fewer cells were engaged. Aggregation was inhibited at 4° C and in the presence of sodium azide or EDTA. Aggregation was also blocked by antibodies to CD11a/CD18. The results suggest, according to Axelsson, that antibodies to LSPG trigger CD11a/CD18-dependent adhesion either indirectly by signalling via LSPG or directly by induction of CD11a/CD18 reactive determinants in LSGP.

B-cell chronic lymphocyte leukemia (CLL) with aberrant expression of CD8 antigen was investigated by L. Borgonovo (Karolinska Institute, Huddinge University Hospital, Stockholm, Sweden). The monoclonal antibodies (Mabs) against CD8 (T-suppressor/cytotoxic) antigen (Leu/OKT 8) were found to bind to leukemic lymphocytes from a patient with a B-chronic lymphocytic leukemia. The B-cell nature of the leukemia was established by the presence of both surface and cytoplasmic monoclonal IgG and by the positivity for B-cell specific markers as judged by staining with Mabs (B<sub>1</sub>, B<sub>4</sub>, and anti-HLA-Dr). In the patient studies, the expression of the CD8 antigen was observed despite normal karyotype and lack of T-cell receptor gene arrangements. The latter was analyzed using probes for the T $\beta$  and the T $\gamma$  genes since these are the first the T-cell receptor genes which rearrange during ontogeny. The B-cell nature of the CLL was further confirmed by Southern blot analysis which demonstrated an additional band of about 14 kilobases, indicative of the rearrangement of the  $\mu$ -heavy chain gene. Thus, according to Borgonovo, these findings clearly demonstrate that the so-called "T-cell specific" markers may be expressed in non-T-cells. Whether this phenomenon represents an aberrant marker expression in tumor cells or a rare but normal B-cell phenotype is not known.

Studies on autonomous protein kinase C (Pkc) activation by cell-surface molecules was presented by B. Friedrich (Institute for Applied Cell and Molecular Biology, University of Umeå, Sweden). CD2 and the antigen-receptor-associated CD3 cell surface antigens represent two independent signal transducing pathways in T-lymphocytes. In the present study, phosphorylation of Pkc substrates in T-lymphocytes was analyzed after a stimulation with specific pairs of anti-CD2 Mabs. The results showed that the appropriate stimulation of the CD2 antigen results in Pkc substrate phosphorylation, and that the conditions required of optimal Pkc activation correlated with CD2 specific induction to autocrine growth in

a quiescent population of CD8 T-lymphocytes. Similar results were also obtained by the appropriate stimulation of the same cell population with the CD3 specific Mab. Thus, by using selected CD2 or CD3 specific Mabs and the appropriate crosslinking of conditions, the results show, according to Friedrich, that triggering of either the CD2 or CD3 antigens alone is sufficient to elicit both full Pkc activation and subsequent autocrine growth. Moreover, since specific activation of the CD2 pathway results in phosphorylation of the CD3 chain, the present study also provides biochemical evidence for a direct linkage between the two activation pathways.

A study on tumor-unique cell surface antigens was reported by C.H. Janson (Department of Immunology, Karolinska Institute and the Immunological Research Laboratory, Karolinska Hospital, Stockholm, Sweden). Mouse Mab antibodies recognizing cell surface molecules on tumor cells from two patients with T-cell chronic lymphatic leukemia (T-CLL) were produced by Janson and his group, working with H. Wigzell, the eminent Swedish immunologist. In one patient, CD3<sup>+</sup>, CD4<sup>+</sup>, and three different types of idiotype-like cell surface structures were identified. One molecule had a relative molecular weight of 90 kDa under nonreduced conditions and 42 kDa upon reduction, corresponding to the T-cell receptor for antigen (T<sub>1</sub>). The two other molecules also behaved as unique tumor markers have not been previously described, according to Janson. One molecule was a monomer with a molecular weight of 74 to 80 kDa in the nonreduced form and upon reduction, 80 kDa. The other idiotypic molecule was a dimer with a nonreduced weight of 74 to 80 kDa. After reduction, a band of 38 kDa was seen. In the other patient, CD3<sup>+</sup>, CD8<sup>+</sup>, one tumor-unique antigen characterized as T<sub>1</sub> has been defined by a Mab of IgG2a subclass. The functional and cytotoxic properties mediated by the antibody were analyzed. A reduction of circulating tumor cells in the patient was seen after intravenous administration of the Mab.

A report on the evolution of the HLA class II region was given by G. Andersson (Department of Animal Breeding and Genetics, Uppsala University and Swedish University of Agricultural Sciences, Uppsala, Sweden). The human class II histocompatibility antigens are encoded by three different subregions of the HLA-D region denoted DP, DQ, and DR. To elucidate the class II antigen repertoire the corresponding genes were isolated and characterized. It was found that the DP and DQ subregions each contains two alpha and two beta genes. In the DR region a

single alpha gene is present whereas the number of beta genes varies between different halotypes. Comparisons of the class II human genes and of the HLA-D region with homologous regions of the mouse and cattle revealed that: (1) the class II  $\alpha$  and  $\beta$  genes are probably derived from a common ancestral gene belonging to the immunoglobulin supergene family; (2) probably early at or before the mammalian speciation a chromosomal segment encompassing an  $\alpha$  and a  $\beta$  gene was repeatedly duplicated to the progenitors of the present-day DP, DQ, and DR subregions; and (3) further duplications within each subregion expanded the gene family which after diversification encodes an increased number of class II antigens. Andersson thinks that it may be assumed that a larger number of class antigens expressed in an individual might be advantageous with regard to the immune response.

The effects of clindamycin on leukocyte membrane receptors and function were studied by A. Ness (Medical Department B, Haukeland Hospital, University of Bergen, Norway). Rosette tests for the demonstration of membrane receptors were performed on granulocytes and lymphocytes after preincubation in various amounts of clindamycin up to 50 mg/l. This compound is an antibiotic which accumulates intracellularly in granulocytes. Incubation in clindamycin was associated with an increase in the proportion of granulocytes and lymphocytes bearing receptors for the Fc portion of IgG (Fc $\gamma$  R) and of granulocytes bearing receptors for C3b (C3bR). Phagocytosis, as measured by granulocyte chemiluminescence, was unchanged after incubation. Preincubation of granulocytes in clindamycin, while causing an increase in the proportion of cells bearing phagocytosis-associated receptors, did not cause an increase in phagocytosis.

A study on the activation-dependent phosphorylation of endogenous PKC substrates in human quiescent T-lymphocytes was reported by K. Noreus (Institute for Applied Cell and Molecular Biology, University of Umeå, Sweden). Activation of quiescent human T-lymphocytes with phorboster, synthetic diacylglycerol analogues and antibodies specific for the antigen-receptor-associated CD3 antigen, results in the rapid phosphorylation of a protein of 80 kDa and a 19 kDa cellular protein. The 80 kDa protein is analogous, according to Noreus, to the previously described putative substrate for the Ca<sup>2+</sup>-activated phospholipid-dependent PKC while the identity of the 19 kDa protein is unknown. Noreus and coworkers showed that this latter protein was variably phosphorylated at serine residues, and three distinct phosphorylation forms ap-

peared after PKC stimulation. Using the 80 kDa and 19 kDa substrates as an assay system, these investigators showed that the appropriate stimulation of quiescent T-lymphocytes with an anti-CD3 antibody resulted in the simultaneous phosphorylation of both proteins. Noreus said that the biological significance of these phosphorylation events is indicated by the correlation with subsequent induction of autocrine growth.

#### B Cells and Antibodies

A study on *in vivo* activated auto-reactive B-cell clones was reported by A. Coutinho (Department of Immunobiology, Pasteur Institute, Paris, France). The number of auto-reactive B-cell precursors in normal nonimmunized mice, has been shown to be highly enriched, for within the pool of *in vivo* activated large B-cells, as compared to the pool of small resting B-cells. In this study Coutinho and coworkers determined the frequencies of anti-bromelain PFC--i.e., a model system currently used for studying auto-reactive B-cells. Limiting dilution analysis (LDA) of small and large B-cells from athymic, nude mice revealed that the frequencies of anti-BMRC PFC were very low and equally distributed among large and small B-cells, in contrast to normal mice where the frequency of anti-BMRC PFC was 10-fold enriched within the large B-cells. Thus, according to Coutinho, T-cells could play an important role in the regulation of auto-antibody production. Nude mice were, therefore, injected with low numbers of various T-cell subsets and later assayed for auto-reactive B-cell precursors within the large and small B-cell compartments. The results demonstrated that T-cell-reconstituted nude mice have frequencies of anti-BMRC PFC similar to normal mice. The increased numbers of auto-reactive B-cells in nude mice are, however, only obtained after reconstitution with certain T-cell subsets, according to Coutinho.

The induction of DNA synthesis and phenotypical changes of activated B-cells was studied by M. Carlsson (Department of Pathology, University of Uppsala and Department of Tumor Biology, Karolinska Institute, Stockholm, Sweden). The resting human B-cell has the option to differentiate with or without proliferation upon physiological triggering by antigen and T-cell and monocyte-derived factors. Carlsson and coworkers had previously described a human monoclonal model for studying B-cell differentiation of phorbol ester (TPA)-stimulated B-chronic lymphocytic leukemia (B-CLL) cells. After TPA activation of the resting GO cells, they enter G1A, as determined by acridine

orange staining of cells measured by flow cytometry. A minority of the cells then become arrested in the G1b phase of the cell cycle. The minimal proliferation measured was due to contaminating T-cells. The B-CLL cells also responded by altering their phenotype to become IgM secretory lymphoblasts-plasmablasts.

Other events studied that were associated with the differentiation were: (1) the induction of the two proto-oncogenes *c-fos* and *c-myc*; (2) the changes in the expression of several surface antigens; and (3) changes in RNA/DNA levels, similar to those observed in mitogen-activated normal human B-cells. Together these results suggest, according to Carlsson, that B-CLL represents a monoclonal B-cell model for GO B-cells inducible to differentiation without concomitant proliferation. In the present study, these investigators showed that significant DNA synthesis is inducible in TPA-exposed B-CLL cells by the addition of BSF containing hybridoma-derived supernatant both under serum and serum-free conditions. Furthermore, it was found that several surface antigens increased their expression by this addition. Carlsson and coworkers also found that the DNA synthesis was not dependent on the contaminating T-cells, which were sorted out by using a flow cytometer. Thus, these investigators have described a model for studying B-cell differentiation with and without concomitant DNA synthesis.

An investigation of the binding of IgG to Fc receptors (FcR) was carried out by B. Heyman (Department of Immunology, University of Uppsala, Sweden). IgG-anti-SRBC (sheep erythrocytes) can suppress more than 99 percent of the anti-SRBC response if injected into mice in close association to the antigen. F(ab')<sub>2</sub> fragments are 1000 times less efficient than intact IgG molecules. Heyman and coworkers investigated which of the effector functions of the Fc part is required for intact feedback immunosuppression. They used two pairs of monoclonal IgG-anti-TNP antibodies: GORK/GORK-Tm and Hy 1.2-M12. Gork-Tm antibodies were produced by GORK hybridoma cells grown in medium containing the glycosylation inhibitor, tunicamycin. These antibodies lacked carbohydrate chains and thereby the ability to activate complement and to bind to Fc receptors, but retained the same antigen binding capacity as the GORK antibodies. Hy 1.2-M12 is a mutant line of Hy 1.2 with impaired ability to activate complement but with the same ability to bind FcR and TNP as wild-type antibodies. These four antibodies were compared, at equal hemagglutinating titers, for ability to suppress the *in vitro* immune response to SRBS-TNP. It was demonstrated

that GORK-Tm was strongly reduced in suppressive capacity compared to GORK, whereas Hy 1.2-M12 was equally efficient as the Hy 1.2, thus indicating a decisive role for the FcR binding in inducing feedback immunosuppression, according to Heyman. This interpretation was confirmed by showing that the monoclonal anti-FcR antibody 24G2 could almost completely inhibit IgG-mediated immunosuppression.

A report on a functional idiotypic network among "naturally" activated antibodies was presented by I. Lundquist (Laboratory of Immunobiology, Pasteur Institute, Paris, France). Lundquist is a member of Coutinho's group. The network theory proposed by Jerne in 1974 opened new perspectives on the regulation of immune responses and led to the demonstration of a potential antibody network. Recently, this group has provided evidence for the existence of a formal idiotypic network in the actual repertoire--that is, among activated lymphocytes and natural antibodies. In order to determine the significance of such idiotypic interactions these investigators have now analyzed normal nonmanipulated BALB/c mice for their serum expression of two complementary idiotypes and have found cyclic expression patterns that seem to be interdependent. Furthermore, immunization with physiological amounts of either idiotypic antibody resulted in drastic consequences for the expression of both. Taken together, these results strongly suggest, according to Lundquist, the functionality of the idiotypic network.

Interferon (IFN)-triggered differentiation of chronic B-CLL cells in serum-free (SF) medium was studied by K. Nilsson (Departments of Clinical Immunology and Pathology, University Hospital, Uppsala, Sweden). SF culture conditions would be preferable when studying the cellular and molecular regulation of B-cell activation, proliferation, and differentiation. Nilsson and coworkers found that 8/10 B-CLL clones cultured in SF medium with phorbol ester (TPA) acquired blastoid morphology and started to secrete IgM, although at levels lower (20 percent) than in serum-containing cultures. Native and recombinant IFN- $\alpha$  and recombinant IFN- $\gamma$  (5 to 100 IU/ml) were found to specifically induce the same changes in most B-CLL clones, and pre-activation of the cells was not needed. None of the agents induced significant DNA synthesis. A panel of Mabs to pre-B (CALLA=CD10) and resting B (HH 1) cells, early (4F2, CD23) and late (CD25, T9) B-cell activation, and terminal plasma cell (T10) antigens were applied to IFN-induced B-CLL cells. Clones responding with IgM secretion lost HH 1 but acquired

the early and late activation markers and T10. CALLA (CD10) appeared on substantial numbers of activated cells. Thus, Nilsson and coworkers think that B-CLL cultured under SF conditions is a useful monoclonal model for studies on the molecular regulation of human B-lymphocytes.

#### Genes and Gene Expression in Lymphoid Cells

The molecular cloning of a membrane antigen complementary DNA (cDNA) from a pancreatic islet cDNA library was reported by M. Altieri (Hagedorn Research Laboratory, Gentofte, Denmark). Naturally occurring autoantibodies have been linked to autoimmune diseases, but they have also been detected in normal humans and animals. In order to study the antigens of natural autoantibodies Altieri and his group produced several monoclonal autoantibodies from unimmunized prediabetic BB/H rats, an inbred strain with high frequency of spontaneous autoimmune diabetes mellitus. Immunoblots of membrane preparations from these rat tissues and seven different rat-transformed cell lines were probed with EA512, one of the monoclonal autoantibodies of the IgM class. In addition, a lambda gt11 cDNA library from rat pancreatic islets was screened with the same antibody, and six independent clones were isolated. The largest clone--a cDNA, 2000 base pairs long--hybridized to the other five clones. A computer-assisted analysis of partial sequences of this clone revealed a strong homology to mammalian Alu-type repeated sequences, probably lying on the 3'-nontranslated sequence of the cDNA, while a sequence thought to be in the coding frame did not show any homology to any known sequence. Thus, the results show the identification and molecular cloning of a new membrane antigen, ubiquitous in most of the tissues but with some specificity in insuloma cells and, perhaps, in pancreatic islets, which is the target of a natural BB/H rat autoantibody.

VH (variable heavy chain) sequence analysis of antibodies with different degrees of degenerate recognition was reported by L. Carlsson (The Unit for Applied Cell and Molecular Biology, University of Umeå, Sweden). Evidence has recently been presented in support of the existence of a formal idiotypic network as well as for the functional consequences resulting from this type of internal interactions. Using collections of B-cell hybridomas of normal mice, Carlsson and his group had previously shown that such idiotypic complementarities occur in very high frequency in the internally activated pool of B-cells in newborn mice. A fraction of these clones have also been

demonstrated to be "multireactive," a characteristic which in newborn individuals appears to correlate with the usage of VH genes of the 7183 VH gene family. In contrast, hybridomas isolated from the same family do not show this correlation, according to Carlsson. In order to investigate the structural basis for this discrepancy, these investigators have now determined the VH and VL (variable light chain) sequences of a number of hybridomas representing either of these two groups.

A study on the regulation of immunoglobulin (IgG) transcription rates in lipopolysaccharide (LPS)-stimulated B-lymphocytes was presented by F. Ivars (Unit of Applied Cell and Molecular Biology, Umeå University, Sweden), in collaboration with M. Davis (Department of Medical Microbiology, Stanford University, California). These investigators prepared constructs of T-cell receptor (TCR) $\alpha$  and  $\beta$  chain genes from the pigeon cytochrome C specific T-cells 2B4 and 5C.C7. For the TCR $\alpha$  chains, the expressed variable genes were constructed from a combination of genomic and cDNA clones. For expression studies in tissue culture cells, two approaches were used: (1) transient expression was assayed by fusing the coding regions of the constructs to the human Cytomegalovirus (CMV) early promoter/enhancer; and (2) the entire genes were linked to selectable genetic markers for stable introduction into lymphoid cells. Ribonuclease (RNase) protection assays indicated that RNA transcribed from the CMV-TCR constructs introduced into L-cells is processed identically to transcripts of the TCR genes in the original T-cells. TCR gene constructs with or without the IgG heavy chain enhancer inserted into the TCR J-C intron were stably introduced into both T-cells (EL4) and B-cells (J558L). RNA analysis indicated that the IgG heavy chain enhancer increases expression of TCR genes by several fold in both T- and B-cells. In addition, transfected lines were found to produce the 2B4 $\alpha$  chain protein as detected by immunofluorescence and immunoprecipitation using a Mab specific for the protein.

A report on the regulation of IgG transcription rates in lipopolysaccharide (LPS)-stimulated B-lymphocytes was given by I.L. Martensson (Department of Immunology, University of Uppsala, Sweden). Mouse splenic B-lymphocytes stimulated with LPS *in vitro* will proliferate and differentiate into IgG-secreting cells. If anti-IGM antibodies to protein kinase C (PkC)-activating phorbol esters are added with the LPS, the B-cells proliferate equally well, but the rate of IgG secretion is greatly diminished,



according to Martensson. This phenomenon is concomitant with decreased steady-state levels of IgM messenger RNA (mRNA), and S1-analysis showed that anti-IgM and phorbol esters suppressed mRNA coding for the secreted form of IgM, showing that these additives affect splicing of IgG primary transcripts. By "run-on" analysis, a decreased rate of transcription of the IgM locus was observed by Martensson and coworkers in cultures treated with anti-IgM or phorbol esters. These investigators conclude that IgG gene expression is controlled at the level of transcription in untransformed B-lymphocytes, unlike what is found in tumors derived from the same cell lineage.

Transient gene expression was studied by T. Leanderson (Department of Immunology, University of Uppsala, Sweden). Leanderson and his group established a protocol for transfection of murine spleen cells by the DEAE dextran method. For this purpose, plasmid constructs were utilized containing the prokaryotic CAT-gene (chloramphenicol acetyltransferase) under regulation of the kappa light chain promoter, the metallothionine promoter, and various enhancer segments. The metallothionine promoter segment gave some CAT expression in the absence of an enhancer, while the kappa promoter did not. Furthermore, the Ig<sub>H</sub> enhancer was active in B-lymphocytes only, with an efficiency comparable to that observed in a B-cell tumor. In T-lymphocytes, CAT expression was observed with the SV40 enhancer but not with the Ig enhancer, while the Ig enhancer was more efficient than the SV40 enhancer in B-cells. Thus, the Ig enhancer is more restricted to the B lineage than the Ig promoter. Therefore, according to Leanderson, this transfection system can be used to study gene expression in untransformed cells.

#### New Immunological Methods

A new technique using immune-scanning electron microscopy for rapid cytomegalovirus (CMV) detection was presented by P.H. Larsson (Department of Immunology, University of Stockholm, Sweden). Mabs, specific for human CMV envelope epitopes, were conjugated to latex microspheres that were already labeled with rabbit antimouse IgG. The beads were incubated with serum or urine from patients, and then collected on a smooth polycarbonate filter surface which was analyzed in a scanning electron microscope. Size, immunological specificity and relative quantity of virus particles were determined within 2 hours in a scanning electron microscope by the visualization of virus particles specifically bound to the microspheres. No virus particles were detected in the various con-

trols. According to Larsson, this method makes it possible to identify extracellular viruses within a few hours in different body fluids and may be used for general virus diagnosis.

Thiophilic adsorption for the purification of monoclonal and polyclonal antibodies from sera and hybridoma culture supernatants was discussed by J. Hoorfar (Department of Animal Physiology and Department of Plant Physiology, Royal Veterinary and Agricultural University and The Protein Laboratory, Copenhagen, Denmark). A new principle of protein fractionation and its use for IgG purification has been described recently. The mechanism for thiophilic adsorption chromatography is unknown, but it resembles hydrophobic interaction, since the binding occurs at high ionic strength and elution at low ionic strength. Under certain conditions thiophilic adsorption is highly specific for immunoglobulins, and can be an alternative method to protein A affinity chromatography, especially when this fails for IgG's of rat, goat, and chicken. Hoorfar's studies involved goat antisera, rat sera, and mouse hybridoma supernatants. For comparison, rabbit and chicken antisera were studied. Both polyclonal and monoclonal antibodies can be purified from crude sera or supernatants according to Hoorfar, but adsorption conditions must be optimized for each application. Hoorfar and coworkers performed batch and gradient elution experiments which were analyzed by electroimmunoprecipitation methods.

The development of a sensitive solid-phase enzyme linked immunoassay for human gamma-interferon was carried out by P. Pisa (Department of Immunology, Karolinska Institute, Stockholm, Sweden). Many *in vitro* as well as *in vivo* studies have shown the importance of  $\gamma$ -interferon ( $\gamma$ -IFN) in immunoregulation. A defect in the production of  $\gamma$ -IFN has been shown in several diseases to cause a higher incidence of viral infections. On the contrary, an overproduction is associated with a depression in bone marrow function. The classical antiviral bioassay for detecting  $\gamma$ -IFN has disadvantages, namely, the cross-reactivity of different interferon classes. Commercially available radioimmunoassay is expensive and requires equipment for handling of unstable radioactive reagents. Therefore, Pisa and coworkers have developed a solid-phase sandwich enzyme-linked immunoassay. It enables the detection of natural as well as recombinant human  $\gamma$ -IFN down to 4 to 8 IU/ml. It employs the combination of an antimurine sera and a murine anti- $\gamma$ -IFN Mab for binding it to the surface and a rabbit anti- $\gamma$ -IFN serum for detecting it. No cross-reactivity



with lymphoblastoid or leukocyte interferon, tumor necrosis factor, or interferon of other species has been detected. According to Pisa, this rapid, reliable, sensitive and highly specific assay is usable for clinical and experimental evaluation of  $\gamma$ -IFN. He and his group are currently testing the  $\gamma$ -IFN production in bone marrow of patients with myelodysplastic syndrome.

A plaque-forming cell assay for identification of anti-DNA antibody-producing cells was developed by V. Andersen (Laboratory of Medical Immunology, Rigshospital and The Hybridoma Laboratory for Autoimmune Serology, State Serum Institute, Copenhagen, Denmark). For the development of a hemolytic plaque-forming cell assay specific for anti-DNA antibody production, Andersen and coworkers used DNA-coated sheep red blood cells (DNA-SRBC), conjugated with the aid of poly-L-lysine. Murine hybridoma cells producing antibodies against DNA, and target cells were incubated in 0.5 percent agarose gel together with secondary antiserum. Complement was added after 30 minutes, and the plaques appeared within 4 hours. The plaques are inhibited by free DNA. No plaques were seen when uncoated SRBC were used as target cells or when DNA-SRBC were incubated with control hybridoma cells producing antibodies against irrelevant antigens. The number of plaques obtained with DNA-SRBC as target cells was found to be identical with protein-A-conjugated SRBC. Preliminary results have shown that by this assay DNA-specific antibody-producing cells can be identified among spleen cells from NZB/W F mice and blood lymphocytes from patients.

The binding of IgE and anti-IgE to peripheral blood cells (basophils) was determined by flow cell cytometry and sorting by P. Matsson (Pharmacia Diagnostics, Uppsala, Sweden). The basophilic leukocyte is involved in the induction of the immediate hypersensitivity reactions, and the cell may also play an important role in late phase reactions. The cells are stimulated to release histamine, leukotrienes, and other inflammatory mediators by the bridging of surface IgE antibodies by appropriate allergens. To allow a thorough evaluation of the basophil frequency--normally 0.5 to 1.15 percent of the leukocyte population--and their degree of IgE binding, Matsson and his group have established a flow cytometric method for sorting and analysis of basophilic leukocytes from human peripheral blood. The cells were labeled either with rabbit anti-IgE ( $F(ab')_2$ ) followed by FITC-conjugated goat anti-rabbit ( $F(ab')_2$ ), or FITC-conjugated IgE, or with IgE followed by anti-IgE. The fre-

quency of basophils, defined as alcian blue staining cells, was determined by microscopy in sorted IgE positive and IgE negative cell populations. The resulting purity of basophils labeled with anti-IgE was 50 to 90 percent. By priming the cells with FITC-conjugated IgE a purity of up to 40 percent of basophils could be obtained. The FITC-conjugated IgE labeled much fewer cells compared to anti-IgE, and those cells were also labeled less intensively. By using the ( $F(ab')_2$ ) fragmented antibodies, the nonspecific Fc binding, normally 6 to 15 percent of the total population, could be avoided. Thus, Matsson said that flow cytometry provides a highly reproducible method to study receptor-bound IgE and free receptors by use of anti-IgE and IgE binding to peripheral leukocytes. In addition, it allows a frequency determination of labeled cells as well as a specific enrichment of cells for further analysis or culturing.

#### Conclusion

The symposia presentations at this immunology conference consisted essentially of reviews of the various areas of immunology research outlined in the introduction to this report. Therefore, all of the selected summaries presented above have been taken from workshop sessions at which new data was given. Since this meeting was a Scandinavian immunology conference, the research work was primarily that of Scandinavian immunologists. It is evident from the presentations that immunology research in the Scandinavian countries is continuing at its usual high level.

9/9/87

#### BIOTECHNOLOGY AT WARREN SPRING LABORATORY, STEVENAGE, UK

by Claire F. Zomzely-Neurath.

The Biotechnology Division of Warren Spring Laboratory (WSL) offers a range of technical and technico-economic expertise to the biotechnologies and manufacturing industries. The group undertakes contract research and development (R&D), consultancy, and multicustomer club ventures. The division has expertise in bioprocess development and innovation, and aids companies in maximizing their share of benefits from biotechnology. WSL has been providing a service to the biotechnology industries for 20 years. Currently, the

Biotechnology Division is active in four areas of processing:

- Downstream processing (BIOSEP), primary separation, membrane processing
- Bacterial genetics, genetic control of auto-flocculation as aids to processing
- Safety (IBC), containment, and risk assessment of bioprocesses, aerobiological monitoring
- Industrial biotechnology, biohydrometallurgy, microbial corrosion, thermophilic bacteria.

The Biotechnology Division possesses comprehensive laboratory and pilot plant facilities and also combines its expertise with that of other divisions within WSL. Created in 1959, the Warren Spring Laboratory and all its divisions is an industrial research establishment of the Department of Trade and Industry.

#### Downstream Processing (BIOSEP)

BIOSEP is a multiclient club venture which has a large membership of fee paying companies from an array of different industries, including the agricultural, food, fine and organic chemical, and medical and pharmaceutical sectors. It provides design information, consultancy, and an extensive R&D program on downstream processing. The service is based in the UK and is managed by WSL and Harwell and is partly financed by the Department of Trade and Industry. Close collaboration between the BIOSEP technical staff and the member companies ensures that state-of-the art and design reports meet the industrial needs of the membership in the most effective way. The extensive R&D program is guided by the member firms and is focused in three areas: (1) primary separation, (2) membrane processing, and (3) chromatography. Half of this program is undertaken at Warren Spring, where primary separation and membrane processing are the major activities; this work is being done at the request of the membership.

Primary Separation. This is defined as those separation activities which are carried out at the start of a downstream processing regime--at the fermentor interface. The separation processes therefore encompass such techniques as whole-broth extraction and broth conditioning, in addition to cell and cell debris recovery. Primary separation is technically difficult and costly, and this is due to the large volume of material that requires processing, the problematical physical and biochemical characteristics of fermentation broths, and the lack of suitable separation processes.



Figure 1. The dielectrophoretic recovery of *E. coli* cells onto an electrode in an alternating (100 kHz) electric field ( $50 \text{ V cm}^{-1}$ ).

At Warren Spring, primary separation is being developed with the aim of reducing the overall costs and complexity of downstream processing regimes by the adoption of novel separative technologies, and by gaining an understanding of the biosurface phenomena associated with primary separation. Two technologies currently being studied at WSL are dielectrophoresis and flocculation. Dielectrophoresis affords the opportunity of selective product recovery from cell and cell debris suspensions. The dielectrophoretic recovery of specific product biocolloids occurs in alternating and nonuniform electric fields. The dielectric phenomenon is dependent on the capacitative action of biocolloids and is unlike electrophoresis. The emergence of new products and processes, the reduction in processing volumes, and the number of process stages are all likely benefits of the application of dielectrophoretic process technology. A laboratory pilot scale separator is currently being evaluated. (see Figure 1).

Cell and cell debris flocculation using synthetic polyelectrolytes is a fundamental part of primary separation in many process regimes. Biosurface studies have revealed a mechanistic understanding, leading to improved control of the beneficial and detrimental effects of flocculant usage. The mechanisms of cell flocculation, and the subsequent detrimental effects of residual flocculant on secondary and tertiary separations, are being investigated (see Figure 2 and 3).

Cross flow membrane separation is now an integral part of downstream processing, although the fouling of membrane



Figure 2. Cell Flocculation.

surfaces reduces the cost-effectiveness of such systems. Microporous and ultra-filtration membranes are prone to fouling and the consequential flux decline, and cleaning operations and membrane replacements can be costly. WSL is improving the performance and economics of membrane processes by applying its knowledge of surface fouling mechanisms. The scientists at WSL are currently evaluating a wide range of commercially available systems, including ceramics (See Figure 4).

**Bacterial Genetics.** Bacterial Genetics is being used at WSL to provide solutions for genetic processing problems. Genetic manipulation is a powerful additional complement to the traditional mechanical or chemical engineering approach to processing. Currently, the main area of research on genetics at the laboratory focuses on the mechanism for controlling bacterial surface properties. Many of the separation techniques (centrifugal cell recovery) and processing problems (fouling of cross flow membranes) encountered during primary separation are inexorably linked with the surface properties of the cells. Control over these cell surface properties becomes feasible from an understanding of the genetics. The scientists at Warren Spring think that such studies will yield significant benefits in improved performance and economics of processing.

Bacterial autoaggregation is dependent on cell surface properties, and this phenomenon is receiving special attention

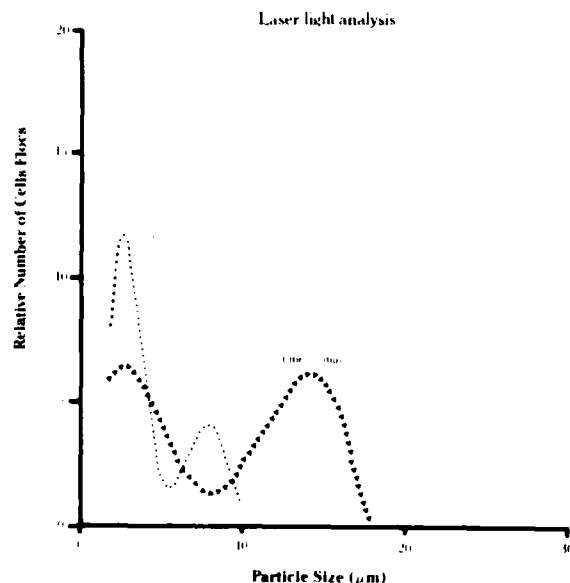


Figure 3. Flocculation of *E. coli* cells by a cationic polyacrylamide.

at Warren Spring. The ultimate objectives of the research program are: (1) the transfer of the aggregation characteristic to bacterial cells which do not normally exhibit this ability and (2) the practical control of bacterial aggregation during a processing regime (see Figure 5). Small bacteria are difficult and expensive to separate and dewater, and hence, many bacterial processes which are carried out at reasonable scales of operation incorporate an aggregation stage prior to cell recovery. Currently, this is usually achieved by the use of expensive chemical additives or physical treatments. Thus, a genetics solution to the problem could avoid the use of additives or complex treatments.

#### Industrial Microbiology

Within the field of industrial microbiology, WSL provides wide expertise in biohydrometallurgy--the application of microbes for leaching metals and removing contaminants from minerals. WSL has developed the biological leaching of metals including copper, nickel, zinc, and uranium from both large lumps of ore and finely ground sulphide concentrates. The scientists at WSL are also using bacteria to pretreat sulphides for enhancing gold recovery and to remove sulphur from coal. In current research they are investigating the generation of useful products--enzymes, for example--from thermophilic and acidophilic leaching bacteria. For

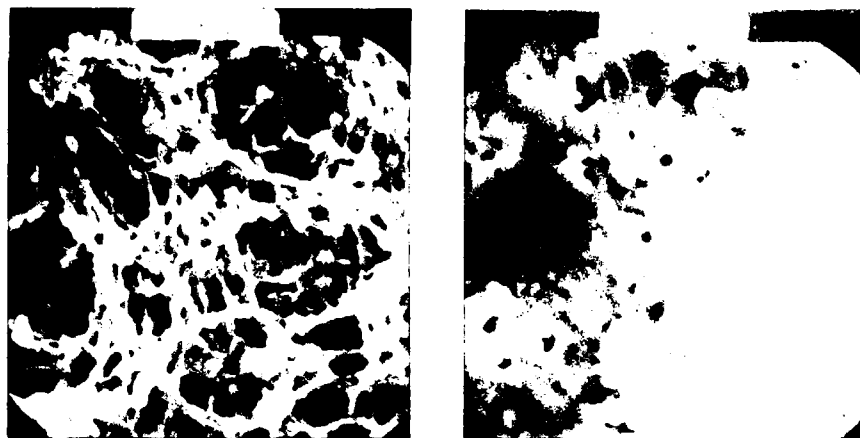


Figure 4. Scanning electron microscopy of a microporous membrane: left, virgin; right, fouled, after passage of a protein solution.

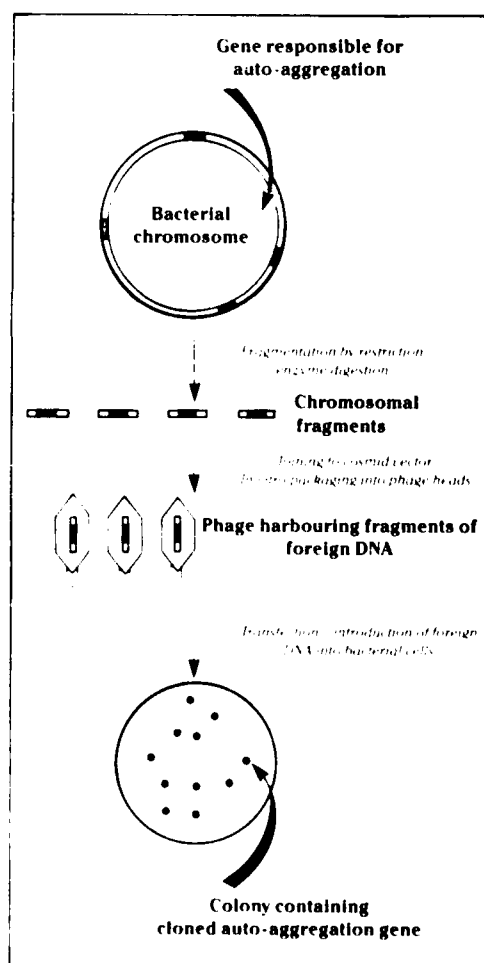


Figure 5. Strategy for isolating a bacterial autoaggregation gene, introducing it into strains of industrial importance in order to facilitate cell recovery and dewatering.

extracting metals, a range of sulphide-oxidizing bacteria, active in acid solutions over a temperature range of 25 to 70°C is being used. In addition, at WSL they also use microbes capable of leaching aluminum, for example, from aluminosilicates. The processes range from simple leaching of clumps of rock to bacterial digestion of fine material under controlled conditions, using stirred or air-agitated reactors. Experiments range from feasibility studies in flasks to continuous leaching on a tonnage basis, using their extensive pilot plant facilities (Figure 6).

In the Biotechnology and Separations Division, N. Le Roux and his group have built up expertise over the past few years in exploiting and understanding bacteria which have abilities and characteristics which set them apart from the more "normal" bacteria. In recent years, the term "extremophile" has become accepted as a broad classification of organisms capable of functioning in relatively harsh conditions of high temperatures, acidity, ionic concentration, pressure, etc. Included in Le Roux's repertoire at WSL are archaebacteria of the *Sulfolobus* genus. In particular, he and his group have a strain which can grow autotrophically while oxidizing reduced iron and reduced sulphur. It has been grown in the presence of copper at pH 6 and 70°C. Currently, it is growing in continuous culture on a feedstock of solid mineral substrate.

The study of the archaebacteria kingdom is still somewhat in its infancy, but there are several potential applications in biotechnology for these organisms. A significant amount of work has been done with thermophile from the *Thermococcus* and *Thermoplasma* genera, but because of their



Biobacterial reactor  
for leaching of metals

Little is known about the biochemistry and physiology of these species. The group are carrying out research on the thermophilic bacterium *Thiobacillus*, growing at 70°C, and are screened for sequences of the genes for leaching in a mesophilic environment. They are also studying the progress obtained by the bacteria in their stable, continuous environment. The bacteria are grown in a continuous culture. The isolation of these bacteria for specific leaching of metals that are of interest as well as the study of the bacteria as bio-

technology. The above described research is part of the Bio-technology program at the Warren Springs Institute, which is engaged in the development of biotechnology.

## Material Sciences

### SIXTH EUROPEAN MICROELECTRONICS CONFERENCE (EMC'87)

The European Microelectronics Conference (EMC'87) was held in Bournemouth, England, from 3 through 5 June 1987, with ISHM-UK as the host chapter. This premier event in hybrid microelectronics in Europe drew more than 650 delegates from 25 countries. In addition, more than 1000 people other than the delegates visited the Trade Exhibition, staged by 153 companies. The competition to present papers at this conference is quite intense; the 60 papers accepted constituted less than one-third of the number submitted. The technical papers were a mixture of basic research and applied research and development, with a noticeable bias toward applied research and development compared to earlier conferences in the series. This indicates a maturing of the field, although there is still a need for fundamental research in a number of areas critical to the technology.

The European Microelectronics Conference is organized biannually by the European Liaison Committee of the International Society for Hybrid Microelectronics (ISHM) so as to alternate years with the Japanese ISHM conference. The 6th conference in the series was held in Bournemouth, England, from 3 through 5 June 1987, with ISHM-UK as the host chapter. This premier event in hybrid microelectronics in Europe drew more than 650 delegates from 25 countries. In addition, more than 1000 people other than the delegates visited the Trade Exhibition, staged by 153 companies. The competition to present papers at this conference is quite intense; the 60 papers accepted constituted less than one-third of the number submitted. The technical papers were a mixture of basic research and applied research and development, with a noticeable bias toward applied research and development compared to earlier conferences in the series. This indicates a maturing of the field, although there is still a need for fundamental research in a number of areas critical to the technology.

This conference series has benefits to the participants other than just the dissemination of technical information in the papers presented. It provides an opportunity for scientists and engineers in the hybrid field, from all over Europe, to get together once every 2 years and compare notes on progress and problems. For many scientists, particularly those from institutions with restricted travel budgets, this is the only conference they attend outside of their native country. The exhibition allows the participants to view the most advanced equipment and materials available to the industry.

There were 60 technical papers presented in 18 sessions dealing with:

- Assembly and processing
- Polymers and materials

- Applications
- Thin films
- Interconnection
- Thermal aspects and substrates
- Design
- Sensors and testing
- Surface mount technology.

A proceedings of this conference is available by writing to ISHM-UK, 117 Evelyn Avenue, Ruislip, Middlesex HA4 8AH, England, UK. The price for a copy of the 494-page proceedings is £29 (\$48 as of today's exchange rate) to members of any ISHM Chapter, and £34 (\$56) to non-members. Since a complete proceedings is available, I will only give a brief review of what I considered some of the highlights of the program.

#### High-Density Interconnection Systems

Recent advances in miniaturization of silicon integrated circuits are creating demands for much higher density interconnection systems, and a wide variety of approaches for different applications were presented at EMC/87. For the high reliability required for aerospace applications, G. Menozzi of Crouzet Aerospace, France, concluded that thick film multilayer ceramic is the best of the currently available technologies. Surface mounting technology using leadless chip carriers offers an intermediate density, but he felt that the growth of this technique will be determined by whether or not the price of the leadless chip carrier becomes comparable to that of the dual inline package. A new and very promising technology for high-density interconnects was the use of the sputtered copper as the conductor and spun polyimide as the dielectric; this was described by M.V. Coleman (Standard Telecommunications Laboratories, UK). Lines and spaces of 50  $\mu\text{m}$  were achieved by photodefining the copper film. While fully polymerized polyimides are inert and are corrosion resistant, it was shown that in the partially cured state fine vias 50  $\mu\text{m}$  by 50  $\mu\text{m}$  could be photodefined to the underlying copper tracks. The amount of cure was shown to critically affect the ability to produce controlled-dimension vias.

A number of technologies for fine line interconnects have been evaluated at GEC Research Ltd., UK, as discussed by J.M. Wheeler. These include etching of thin print thick film conductors, photodefinition and plating up of metallo-organic prints, and advanced printed circuit board techniques, but GEC's preference is traditional thick film screen printing. They have shown that, with careful selection of screen materials using high-resolution emulsions combined

with the most advanced thick film inks, they could produce hybrids using 125- $\mu\text{m}$  design rules.

The photoformed ceramic substrate (PCS) described by D. Deduk of DuPont (Deutschland) GmbH, West Germany, is a novel system for metal powder images transferable into corresponding fine line conductors. The PCS process consists of coating the substrates with a thin amorphous layer of a mixture of nitrophenyl dihydropyridine derivatives, and exposing this layer through a mask to UV light, thereby transforming it into a tacky state. Spherical gold powder in the size range 1-2  $\mu\text{m}$  is then spread over the substrate, and the particles adhere to the exposed tacky areas. This step is followed by conventional thick film firing. The PCS process creates high-resolution conductors with capabilities of 25- $\mu\text{m}$  lines and spaces, and excellent edge definition.

#### Materials in Hybrid Technology

The number of papers dealing with the materials aspects of hybrid technology were considerably fewer than at previous conferences in this series, but the ones that were presented were quite interesting. Studies at the University of Modena, Italy, of the kinetics of dissolution of alumina substrates into different thick film glasses for different firing times and temperatures showed that diffusion was the rate-limiting process in all cases, and that the composition of the glass greatly affects the kinetics of dissolution. The amount of substrate dissolved during typical thick film firing was also studied, and it was found that the final composition of the glass contained 10-20 percent dissolved substrate; this is an appreciable effect.

The development of a process for producing small, spherical, uniform-size gold powders for use in a new generation of gold thick film inks for printing fine line conductors was described by R.L. Stewart of Johnson Matthey Materials, UK. The gold powder is produced by chemical reduction from aqueous solution, and the critical part of the process is the use of a colloidal gold with particle size 100-200  $\text{\AA}$  as seeds upon which the gold is deposited from solution. A surface active agent was used to retard the formation of new nuclei, and the seeds were grown to the required size by control of the amounts of gold and reductant in solution. The resulting gold powders were monodispersed and spherical, and could be manufactured to any predetermined diameter in the range 0.3-1.5  $\mu\text{m}$ . Using these gold powders to make thick film inks, the company has achieved 35- $\mu\text{m}$  lines and

spaces in the laboratory and 75- $\mu$ m lines and spaces in production.

#### Surface Mount Technology

There were many papers at EMC/87 which dealt with surface mount technology (SMT) in one form or another. This is understandable considering the results of an ISHM Europe hybrid market survey reported at the closing session of the conference. The survey showed that in 1980, SMT on printed circuit boards (PCB) counted for less than 1 percent of the total hybrid market, but had increased to 10 percent by 1986. Even more impressive were the estimates for 1990 provided as part of the market survey, which predicted SMT on PCB accounting for 38 percent for the total hybrid market.

A survey for automotive electronics presented by R. Dell'Acqua of Marelli Autronica SpA, Italy concluded that SMT will dominate during the 1990's in all its varieties. Surface mounted thick film hybrids will keep their share for under-hood applications, and surface mounting on PCB's will cover the inside passenger compartment applications. It was also predicted that surface mounting of naked chips on ceramic will grow through the 1990's to fulfill the environmental and reliability requirements for the engine compartment electronics. In domestic telecommunications, J.P. Kandall of British Telecom, UK, predicted that SMT on PCB will continue to be the dominant technology in telephone exchanges and in the home, which leaves out-station electronics in the local network, where the circuits must function over a wide temperature range, as the only mass market left for ceramic hybrids.

With all of the interest in SMT, it was fitting and proper that the last paper of the conference--by P.L. Kirby of Welwyn Electronics, UK--was a historical discussion of interconnection technology. Surface mount technology was shown to trace its origins back at least 35 years, so it is by no means a new technology. The very rapid growth in the last few years was shown to be due to its fortunate compatibility with other emerging technologies to make a synergetic situation. Surface mounting is emerging as an important and coherent subject, which, when viewed in light of the development of computer controlled electronic assembly techniques, can claim to be the fourth generation of interconnection technology.

#### Summary

One thing that was very apparent from the technical program at EMC/87 was how far the technology has moved from the concept of the hybrid and an assembly of

devices on a ceramic substrate usually interconnected by thick film materials. There were papers covering many alternate interconnection technologies including tape automated bonding, surface mount on PCB, metal core substrates, additive thin film, and a variety of fine line technologies. Many of these new techniques were in development and close to production. Hybrid microelectronics is a rapidly developing industry that is creating opportunities as the interface between the ever-increasing complexity of silicon compounds and the needs of the physical world.

#### CREEP AND FRACTURE OF ENGINEERING MATERIALS AND STRUCTURES--THIRD INTERNATIONAL CONFERENCE

*Dr. J. J. Burke, Dr. J. J. Burke was a Visiting Professor at the Fraunhofer-Institut für Materialprüfung in Freiburg, Germany. He returned to his position as Head of the Metals and Welding Division of the Naval Ship Research and Development Center in Annapolis, Maryland, in July 1987.*

The third in a series of international conferences dealing with creep and fracture of engineering materials was held in April 1987 at the University College of Swansea, UK. This conference was chaired by Professor B. Wilshire and Dr. R.W. Evans of University College of Swansea, and attracted 120 attendees. Most of the attendees were from Western Europe, with 16 from the US, 14 from the Far East, and individual representatives from USSR and Czechoslovakia. ONRL provided partial financial support, and additional support was provided by the Institute of Metals, the European Office of Aerospace Research and Development, and the US Army Research, Development and Standardization Group, UK. Publication of the proceedings (edited by B. Wilshire and R.W. Evans) prior to the start of the conference was accomplished through the Institute of Metals, London, UK, and is available from the institute for \$110.00.

The conference topics were divided into the following categories, where the bracket contains the number of papers presented:

- Mechanisms of creep and creep fracture [16]
- Deformation and fracture of particle-strengthened alloys [9]

- Creep and fracture of steels [8]
- Damage accumulation and creep crack growth [9]
- Deformation and fracture under combined creep fatigue conditions [7]
- High-temperature behavior of welds [6]
- Creep data prediction and remanent lift assessment [13]
- High-temperature performance of engineering ceramics [7].

Because the selection of topics was extensive, and the number of papers in most categories limited, the "research in progress" theme was evident in many areas. Also, because of the large number of papers, I have chosen to discuss only those which I believe are most significant in the areas of my own interest.

#### Mechanisms of Creep and Fracture

The session on mechanisms of creep and creep fracture generated the most interest and discussion. The first speaker presented an analysis of noncompact glide in Al single crystals, which included a formulation of a kink pair dislocation model to describe temperature, strain-rate, and stacking fault energy dependence of noncompact glide. M. Kassner (Lawrence Livermore National Laboratory) reported results of a study of the deformation of high-purity aluminum in torsion at 644 K to various primary and steady-state creep strains. Transmission electron microscopy TEM observations showed that at the onset of steady-state, all the subgrain boundaries had a small misorientation, which changed to a bimodal distribution as strain increased. His paper concluded that a description of the rate-controlling process of creep should include the density of dislocations not associated with subgrain boundaries.

A modification of the stress and strain transient dip test to measure internal stress as the athermal component of the flow stress was introduced by Z. Horita (Kyushu University, Japan). The key element of his paper was the introduction of an extrapolation procedure requiring measurement only of the total time from onset of stress reduction to the termination of the period of zero creep. Reanalysis of results of previously reported transient dip experiments led to the conclusion that the recovery process was due to growth of three-dimensional dislocation networks. Results of stress dip tests of a number of fcc and hcp alloys in order to determine the internal stress under conditions of steady-state creep was reported by Northwood and Smith. They found that the ratio of internal stress to external applied stress for pure metals was typically 0.9 to 1.0

regardless of crystal structure, 0.8 to 0.9 for Class II solid solution alloys where climb is rate controlling, and approximately 0.7 for Class I solid solution alloys where viscous glide is rate controlling. The multiphase commercial alloys exhibited internal/external stress ratios similar to pure metals.

M. Mills (Lausanne Federal Polytechnic, Switzerland) and W. Nix (Stanford University, California) performed extensive TEM investigations of Al-5.5-percent Mg to determine the dislocation substructure during creep, including *in situ* heating to simulate a large stress decrement. Dislocation loops were seen to be a primary feature of the creep substructure, in agreement with a previously developed dislocation loop model. The authors suggested that anelastic strains measured after stress decrements are due to a dislocation runback mechanism, and not the action of long-range internal stress. The papers dealing with internal stress measurement led to discussion of their theoretical and physical basis, the resolution of which seemed to be agreement over terms and the basic framework in which such stresses are to be postulated.

Two papers addressed changes in the power law creep behavior of metals. H. Oikawa (Tohoku University, Japan) reported that bcc, fcc, and hcp alloys change their creep behavior with increasing stress, where recovering appeared to be rate controlling, and where the stress level for deviation was determined by solid solution hardening with immobile solute atoms in the matrix. Z. Horita (Kyushu University) and others presented results of two experiments to evaluate the deviation of the stress exponent from the value of 3 for Al-Mg alloys. These included precise measurement of this deviation as a result of solute concentration, and superposition of an ultrasonic oscillatory stress during high-temperature deformation. Both sets of results were interpreted in terms of effective component of the dislocation velocity.

θ Projection. The most discussed (if not controversial) topic of the conference involved the  $\theta$  projection concept by R. Evans and B. Wilshire (both of University College Swansea, UK). The basis for this approach is the assumption that normal creep curves are composed of the sum of decaying primary and accelerating tertiary components. The variation of creep strain with time is described in terms of an exponential expression containing four coefficients, two of which act as scaling terms defining the extent of the primary and secondary stages with respect to strain, while the other two are rate



parameters governing the curvature of the primary and secondary components. Constant stress creep data obtained for polycrystalline copper over the temperature range of 604 to 774 K were used in a nonlinear least squares regression to determine the best fit for the coefficients. Variation of these coefficients with stress and temperature were also determined, and the authors postulated that dislocation movement was enhanced by dislocation diffusion. Because neither grain growth nor recrystallization occurred, it was further postulated that tertiary creep was a consequence of a gradual increase of creep rate as the number and size of cavities increased with strain. From extrapolation of the calculated coefficients and stress/temperature relationships obtained over a narrow temperature range, a family of minimum creep rate curves was predicted for various temperatures, and found to coincide with the data. Evans and Wilshire also concluded that power law breakdown and the transition to low  $n$  values were also accurately predicted. Additionally, a "pseudo deformation mechanism map" was constructed using arbitrarily selected values of  $n$  for diffusional creep and power law breakdown, and an assumed activation energy dividing diffusional and dislocation creep fields. Agreement with a published deformation mechanism map was shown, and the authors suggested that such maps could be viewed as the consequences of the variation of the creep curve shape with temperature. They suggested that no change in mechanism need to be postulated to explain the change in creep exponent.

In a later session addressing component life, three additional papers addressing the  $\theta$  projection concept were presented. S. Brown (University College Swansea) examined four equations describing creep strain as a function of time, using nonlinear optimization techniques to fit constant stress creep data for 0.5Cr-0.5Mo-0.25V steel obtained at a variety of stresses at 838 K. The coefficients of each expression were then used to predict rupture life for various stress levels, and the  $\theta$  projection was seen to be superior in its predictive capabilities. Dr. Li (Daye Steel Corporation, China) and others examined the applicability of the  $\theta$  projection with IN-738. In this study, values of the coefficients were determined for sequentially increasing stress levels. It was pointed out that although structural changes and changes in creep mechanism occurred, the  $\theta$  parameters followed a simple linear function. K. Maruyama and H. Oikawa (both of Tohoku University) formulated a five-parameter expression

for creep curve fitting. For the case of ferritic CrMoV steels, they postulated that one of the rate constants appeared to be related to diffusion, and examined the materials-dependence of the strain hardening and strain weakening parameters.

From the questions and discussion associated with the  $\theta$  projection papers, it is likely that this topic will receive increasing attention in the near future. Its proponents claim success in accurately predicting long-term creep data by extrapolation, but many are seeking fundamental bases for such successes, and verification of predictive ability. Because of reported insensitivity of metallurgical mechanisms operating in creep, I anticipate more attempts to ascribe fundamental physical significance to the fitting coefficients, and to evaluate their applicability among various materials.

The Role of Metallurgical Structures and Impurities. The creep mechanism sessions were concluded by several papers related to the role of metallurgical structure and impurities in the creep process. R. Gifkins (Monash University, Australia) reviewed the calculations of stress components for creep and grain boundary sliding. He concluded that the latter is equal to that for creep except for limited cases, and warned experimenters about recognizing transition. T. Watanabe (Tohoku University) discussed structure-dependent intergranular creep fracture. Because grain boundary sliding and fracture were seen to occur preferentially at high-energy grain boundaries, Watanabe postulated that decreasing their frequency, producing a regular distribution of high- and low-energy grain boundaries when the frequency of the high-energy boundaries is low, and control of grain boundary inclination may be effective in suppressing creep.

Dr. Li (Daye Steel Corporation) and others reported results of a very well designed investigation of the nucleation of creep cavities in iron containing controlled additions of sulphur, phosphorus, and carbon. They found that the cavitation process depended strongly on the sulphur level, particularly above the solubility level for a particular temperature. They also concluded that ease of nucleation at grain boundary particles depended strongly on the type of particles, where sulfides provided the most profuse nucleation sites.

J. Mintz (Sandia National Laboratories, New Mexico) studied the growth of grain boundary cavities in copper and nickel through use of the tritium-to-helium decay reaction to nucleate voids. The results showed that cavity growth for

nickel (under certain conditions) was controlled by grain boundary diffusion, where copper exhibited matrix-plasticity-controlled diffusional growth. This paper concluded that coupled models were required to adequately describe the kinetics of cavity growth under creep conditions.

#### Deformation and Fracture of Particle-Strengthened Alloys

The session on deformation and fracture of particle-strengthened alloys was notable mostly for the variety of materials investigated. These included:

- Oxide-dispersion-strengthened nickel-base superalloys
- TiN-dispersion-hardened 20-percent Cr-25 Ni stainless steel
- Nickel-modified high-temperature cobalt superalloys
- Ferritic Fe-Ni-Al alloys containing ordered precipitates
- Directionally solidified Al/CuAl eutectic composites
- Bismuth-doped directionally solidified Mar M002
- SiO<sub>2</sub>-dispersion-hardened nickel-base alloys
- Mechanically alloyed Al-Mg alloy containing oxide and carbide dispersions
- High-temperature Al-Zr-V alloy from rapid solidification processing.

The focus of the papers ranged from modeling of creep and strengthening mechanisms to introducing new alloy concepts and production methods. Key theoretical contributions included the formulation of a kinetic model for dislocation climb over dispersion particles which treated the dislocation shape in the vicinity of the particle and the effects of an attractive interaction between dislocations and particles in the climb process, and a mechanistic model of the dislocation creep of particle-hardened materials between threshold and transition stresses.

R. Lewis (Lockheed Missiles and Space, US) presented results of attempts (by him and others) to produce an Al<sub>3</sub>(Zr, V) metastable precipitate-strengthened aluminum alloy from a variety of rapid solidification techniques in order to achieve 5- to 15-percent precipitate without losing ductility at room temperature. To complete this materials perspective, Benn introduced a new class of oxide-dispersion-strengthened superalloys, and presented long-term stress and creep rupture data in comparison with conventional superalloy formulations.

Creep and Fracture of Steels. The session on creep and fracture of steels was highlighted by a group of presentations which addressed the performance of

stainless steels. T. Nakazawa (Nippon Steel Corporation) evaluated the effects of carbon, nitrogen, and phosphorous on creep and rupture ductility of high-purity Ni-Cr austenitic stainless steel. C. Shepherd (UK Atomic Energy Authority) discussed the creep-strengthening mechanisms in austenitic stainless steels, concentrating on the roles of phosphorous in the reduction of minimum creep rate, and possible causes of embrittlement by tin additions. R. Sandstrom (Institute for Metals Research, Sweden) presented a paper evaluating the creep properties of a carbon 21Cr-11 Ni-0.15 N, 0.05-Ce austenitic stainless steel, where the carbon, nitrogen, and cerium contents were varied. Although these papers did not include detailed modeling, they addressed key metallurgical factors in the creep and fracture processes.

#### Damage Accumulation and Creep Crack Growth

The topics of damage accumulation and creep crack growth were addressed through a combination of theoretical papers dealing with creep damage from the solid mechanics and micromechanistic viewpoints, and interesting evaluations of component behavior considering creep crack growth. R. Pilkington (University of Manchester, UK) investigated creep damage accumulation in a Cr-Mo low alloy ferritic steel to assess effects of multiaxial stress and relate microscopic damage to macroscopic fracture parameters. He and his coauthors formulated a modification of the Hull-Rimmer cavity growth model which, when coupled with continuum damage constitutive expressions, was seen to reasonably predict creep cavitation damage and macroscopic creep strain. G. Webster (Imperial College, UK) introduced an assessment procedure for cracked components based on the C\* fracture mechanics parameter (including two case studies) where uniaxial creep data was employed to assess welded pressure-vessel performance. As anticipated, defects in the weld metal and HAZ proved difficult to treat because of effects of residual stresses and stress redistribution. In a complementary paper, T. Hollstein (Fraunhofer Institute, West Germany) presented experimental and numerical results where creep crack growth rates of IN 617 at 900°C were correlated with the C\*-integral. Utilizing a stationary numerical simulation for limited creep crack growth, they showed good agreement with experiment, suggesting promise for such an approach for component assessment.

The papers addressing combined creep-fatigue conditions addressed ambient-temperature as well as elevated

temperature creep and damage accumulation. W. Evans (University College of Swansea) evaluated creep-fatigue of alpha-beta-processed Ti-6Al-4V, showing that low-temperature creep is responsible for an observed sensitivity to dwell under cyclic loading conditions, and attributed the initiation of subsurface cracks to time-dependent strain accumulation. M. Winstone (Royal Aircraft Establishment, UK) and coauthors proposed a physical model for cyclic creep of near-alpha titanium base on weakest link statistics, where local strain inhomogeneities were seen to produce stress concentrations within large components. H. Cortie (University of Witwatersand, South Africa), on the other hand, evaluated the acceleration of creep crack growth in Cr-Mo steel in an attempt to sort out the roles of creep and environment. His papers concluded that a synergistic creep-fatigue-environment interaction exists, which must be necessarily modeled in a coupled approach.

#### Remanent Life Assessment

The session on remanent life assessment and creep data prediction included papers on the  $\theta$  projection concept and its modifications which were noted earlier in this summary. M. Steen (State University of Ghent, Belgium) and M. DeWitte (Laborelec, Belgium) presented a pair of papers dealing with structural instability as related to the extrapolation of short-term creep test results. They showed that short-term constant strain rate creep tests could be used to predict creep rate over a wide range of stresses and temperatures provided microstructural thermodynamics equilibrium is maintained. Time-to-rupture extrapolations from constant strain rate tests agreed well with extrapolation of constant stress tests where the microstructure (in this case for steels) was constant. The importance of structural instability in data extrapolation was discussed. B. Cane (Central Electric Generating Board, UK) reviewed the status of remanent creep life assessment methodologies for power and process plants, focusing on low-alloy ferritic steels. He identified areas of required investigation to bridge gaps in assessment capability, particularly related to aged materials and those undergoing weld repair. F. Masuyama (Mitsubishi Heavy Industries, Japan) presented very interesting results where creep damage was assessed from the evaluation of profiles of element concentration spectra by means of computer-aided x-ray microanalysis. A correlation was seen between spheroidization of precipitates and creep damage, which was then linked with creep rupture life consumption rate. P. Auerkari (Tech-

nical Research Center of Finland) and P. Vieros (Imatran Voisna Oy, Finland) postulated the possibility of predicting residual life fraction in a uniaxial creep test using a relation between cavitation and strain, thus pointing to a basis for use of cavitation measurement to assess creep conditions in high-temperature steam piping.

The conference was concluded with a session devoted to elevated temperature performance of ceramic materials. A.G. Evans (University of California) highlighted this session by a very thorough review of the fundamental principles involved in high-temperature flow and fracture of ceramics and ceramic composites. This review included creep crack growth, crack blunting, flaw, nucleation and stress corrosion. He concluded that models are required to incorporate the viscoelastic character of the ceramic with microstructural events such as grain boundary sliding.

#### Summary

This conference provided an excellent forum for scientists and engineers dealing with creep and fracture of materials to exchange their most recent results, and to assess progress. This was aided by the availability of the proceedings prior to the meeting which led to rigorous discussion of many of the papers. Because the conference was the third of this series, all of which have been held in Swansea, there was a clear sense of continuity in many of the papers and topic areas, and this series appears to be targeted by many participants for future contributions.

#### Reference

Wilshire, B. and R.W. Evans, "Creep and Fracture of Engineering Materials and Structures," *The Institute of Metals*, London, UK (1987).

8/26/87

#### SIALON CERAMICS RESEARCH AT THE UNIVERSITY OF NEWCASTLE-UPON-TYNE

by Louis Cartz. Dr. Cartz is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Marquette University, College of Engineering, Milwaukee, Wisconsin.

#### Introduction

The pioneering work of Professor K.H. Jack and his research group at the

University of Newcastle-upon-Tyne on sialon ceramics is well known. The work has led to the development of sialon ceramics, many of which are marketed by Lucas-Cookson-Syalon Ltd., UK; these sialons are produced under license by, for example, Sandvik Hard Materials AB (Sweden). Since the retirement of Professor Jack in 1984, the research group at Newcastle has continued under the direction of Dr. Derek P. Thompson. The main thrust of the research has continued to be in the preparation and characterization of sialon materials for high-strength, high-temperature engineering applications. Several of these studies are described in paragraphs following.

#### The Glassy Phase at the Grain Boundary

Sialons form useful materials but contain a grain-boundary (GB) glassy phase and so suffer a degradation in properties at about 1000°C. This glassy GB phase is formed from the sintering additives, which are required to prepare high-density solids. Extensive work at Newcastle has been carried out on the Y-Si-Al-O-N sialon ceramics using yttria as the sintering aid, which results in the formation of a crystalline material at the GB consisting of yttrium aluminum garnet (YAG),  $Y_3Al_5O_{12}$  (Slasor et al., 1985; Walls and Thompson, 1986). The conversion of the glassy phase at the GB to YAG extends the upper temperature limit to about 1300°C, above which degradation by oxidation and creep mechanisms seriously restrict high-temperature usage. Current research at Newcastle is concentrating on improved densification cycles with controlled mixtures of additives to produce specific refractory GB phases which improve the high-temperature performance. Since alumina reduces the eutectic temperature in the Y-Si-O-N system by at least 200°C, mixtures of oxides other than alumina are being explored. In the  $MgO-Y_2O_3-Si_3N_4$  system, the pyroxene phase  $MgYSi_2O_5N$ , which can be produced as a secondary grain boundary phase, allows reasonable refractory performance up to 1450°C, but this material suffers from the catastrophic low-temperature oxidation behavior exhibited by melilite-containing ceramics. Fortunately, this problem can be overcome by the recently developed flash oxidation techniques (Govila, 1987).

Work is being undertaken on the possible use of  $Nd_2O_3$  to replace  $Y_2O_3$  as the sintering additive (Slasor et al., 1986).

#### Silicon Carbonitrides

The Newcastle group's interest in phase relationships continues with an investigation of the C-Si-Al-O-N system

for new phases and promising refractory compositions. Attempts are underway to form materials of composition  $Si(C,N)$ . Such compositions are being explored for their high-temperature electrical properties.

#### Nitrogen Glasses

Worldwide interest in nitrogen glasses has focused mainly on the improvement of the mechanical and thermal behavior properties of nitrogen glasses compared with oxide glasses; optical properties of nitrogen glasses have not been explored because they are opaque. Recent transmission electron microscope work has shown that this opaqueness is due entirely to a dispersion of iron silicide particles in the glass. By using pure starting materials, transparent glasses can be produced (see Figure 1). Glasses can be prepared with no ppt at all. The specimen of Figure 1 has been chosen so that the nature of the ppt can be seen.

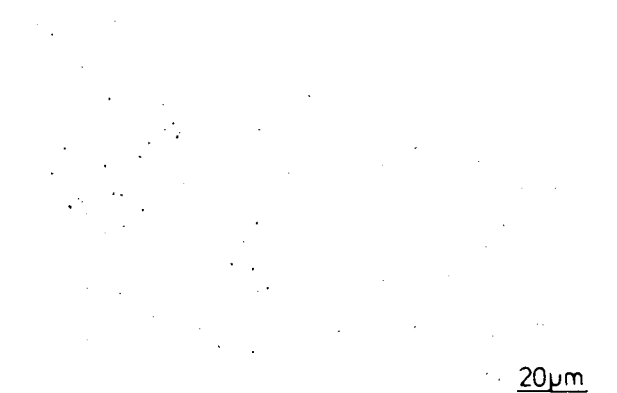
The Newcastle group is exploring crystallization of nitrogen glasses to yield glass ceramics because of the dielectric and superior mechanical properties of glass ceramics. The ceramics of  $\beta''$  magnesium sialons, which can be crystallized by using  $\beta'$  sialon as a nucleating agent, are low-loss materials. The increasing range of crystalline oxynitrides offer alternative possibilities (Jameel and Thompson, 1986). The use of zirconia to improve the low-temperature mechanical performance of glass ceramics is also being investigated. The variables of quenching treatment and the amount of stabilizing agents in the starting glass composition offer prospects for good control of the mechanical properties of the final material.

#### Magic Angle Spinning Nuclear Magnetic Resonance (NMR)

New analytical techniques are important for the characterization of high-performance ceramics. A research program in collaboration with Professor R.K. Harris at nearby Durham University, is currently exploring the usefulness of magic angle spinning NMR as applied to engineering ceramics. In magic angle spinning NMR, the effect of the aligned dipoles of the crystal structure can be excluded, as well as the effect of chemical shift anisotropy on the line width. The resonances from sites of different local environment are readily detectable, (Dupree et al., 1985). One important use of this is the study of the coordination of  $^{29}Si$  and  $^{27}Al$ ; silica on the surface of grains of silicon nitride powder can be identified and distinguished from  $SiO_2$  from within bulk silicon nitride. The



(a) Low magnification showing general transparency.



(b) Optical micrograph of some glass slab where precipitates can be seen.

Figure 1. A Mg-sialon glass slab containing fine precipitates of an Fe silicide.

sensitivity of this technique for detecting grain boundary glass phases is being examined.

#### Modeling of Ceramic Behavior

The arrival of Dr. Howard Chandler in 1985 on the staff of Newcastle's Metallurgy and Engineering Materials Department broadened the existing expertise in ceramics to include mathematical modeling and behavioral studies on the impaction of starting powders and improved methods of ceramic fabrication.

#### Conclusion

The research group led by D.P. Thompson have made very interesting progress in a series of studies, including:

- Nitrogen glasses and their transparency
- Glassy and crystalline GB phases and their role in catastrophic oxidation above 1000°C
- Refractory GB phases to reduce high-temperature creep
- The possibility of preparing Si(C,N) compounds
- Nitrogen-pyroxene compounds (a new class of nitrogen-containing crystal structures)
- A useful high-temperature ceramic at 1500°C formed by Si<sub>3</sub>N<sub>4</sub> with less than 10 percent Y<sub>2</sub>O<sub>3</sub> additive.

Although the group is relatively small in number, their results are most impressive.

#### References

- Dupree, R., M.H. Lewis, G. Leng-Ward, and D.S. Williams, "Coordination of Si Atoms in Silicon Oxynitrides Determined by Magic Angle Spinning N.M.R.," *Journal of Material Science Letters*, 4 (1985), 393-395.
- Govila, R.K., "Fracture of Flash Oxidized, Yttria-Doped Sintered Reaction-Bonded Silicon Nitride," *Journal of Materials Science*, 22 (1987), 1193-1198.
- Jameel, N.S., and D.P. Thompson, "The Preparation of Nitrogen Glass Ceramics in the Magnesium Sialon System," *Special Ceramics*, 8 (1986), 95-108.
- Slasor, S., and D.P. Thompson, "Preparation and Characterization of Yttrium α'-Sialons," *Non-oxide Technical and Engineering Ceramics*, Limerick, ed. S. Hampshire (1985) (in press).
- Slasor, S., K. Liddell, and D.P. Thompson, "The Role of Nd<sub>2</sub>O<sub>3</sub> as an Additive in the Formation of α'-Sialons," *Special Ceramics*, 8 (1986), 51-63.
- Walls, P.A., and D.P. Thompson, "Reaction Mechanisms in the Formation of Calcium and Yttria α'-β' Sialon Composites," *Special Ceramics*, 8 (1986), 35-50.

9/24/87

## Mathematics

### ARTIFICIAL INTELLIGENCE AND RELATED RESEARCH AT SALERNO

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1988.

In continental Europe, one may find Artificial Intelligence (AI) research disguised by unusual names, and pursued in diverse academic departments where one would not expect it. For example, at the young (less than 15 years old) University of Salerno (southern Italy), excellent, interdisciplinary AI work is done, under the title of "Cybernetics," in the Department of Theoretical Physics, which also carries out notable research in the "standard" topics, including superconductivity and elementary particle theory. The allocation of AI to the theoretical physics department is particularly odd, since the Faculty of Science does have a Department of Informatics, and the Faculty of Engineering even has a Department of Computer Science.

These (and other) peculiarities are closely related to the personality and professional history of Professor E.R. Caianiello, currently the Head of the Department of Theoretical Physics. He, a well-known quantum field theorist, first became interested in the collective behavior of large systems with a complex structure in the early 1960's, when he was Head of the Theoretical Physics Institute of the University of Naples. Since, apart from such systems specifically related to the simulation of intelligence, he was drawn to more general structures (including natural languages, biological systems, and social systems), he found it appropriate to refer to his efforts by the classic term *cybernetics*. But, he told me recently, it has been always "crystal clear" to him that actually "the true and ultimate object of cybernetics is the study of intelligence. Moreover, calling it 'natural' or 'artificial' is misleading and leads only to confusion." In 1968, Caianiello became founder and director of the Italian National Science Council's independent Institute for Cybernetic Research, at Arco Felice. This led to further diversification of Caianiello's outlook. Finally, when in 1973 he became the Founding Dean of the Science Faculty at

the University of Salerno, he took along his best coworkers (from both his previous posts) and placed them in the Department of Theoretical Physics so as to ensure both a basic, broadbased interdisciplinary activity and an atmosphere which distinctly differs from the run-of-the-mill version of AI-related research. In particular, Caianiello emphasizes that his and his half-a-dozen permanent associates' work is searching for the understanding of various areas of structure in complex systems. The coexistence and interaction of so many structures (atoms, humans, the universe, and all there is in between), he says, would be inconceivable if there were not, behind it all, some general organizational principles. And, he adds, theoretical physicists are eminently suited to perform analysis of this kind. Of course, the laws that determine the behavior of complex systems (including intelligent systems) are not of purely physical nature (like Newton's laws); rather, they have a *logical* nature, connected with information, entropy, hierarchy. Furthermore, Caianiello points out the almost obvious fact that the study of structure is epitomized by the notion of "complexity." In order to approach AI reasonably (and more modestly than is the custom these days), we must learn simple mathematical ways "to catch what is really essential in phenomena which occur only in systems with large numbers of components and of interactions."

The philosophy, outlined above, brought Caianiello's group in close contact with other internationally respected AI researchers and groups: Bruxelles University, the Los Alamos Laboratory, the Tübingen Max Planck Institute for Biological Cybernetics, the Biocybernetic and Medical Engineering Laboratory at the Polish Academy of Science, and the Cybernetics Research Effort of the Soviet Academy of Sciences. (Contacts with commercial outfits, so typical for other AI research centers, are notably absent.)

Current research at Salerno under the leadership of Caianiello can be characterized by the following headings:

- Neural nets and cellular automata
- Hierarchical systems
- Composite sets
- Mathematical linguistics.

Clearly, these areas overlap, since, for example, the linguistics research here is especially concerned with the hierarchical sequence that begins with concepts such as "letters-syllables-words..."; moreover, composite set theory has proved particularly efficient in automatic ("semi-intelligent") pattern

recognition. In addition, "practical" concentrations in robotics, memory, perception, also pursued at Salerno, clearly are related to the listed thematic areas. In any case, Caianiello considers the long-range goal of his group to be the understanding of "general architectures for total brain activities."

In order to illustrate the flavor of research at Salerno, I will make a few comments on the neural nets and on the composite set research areas.

#### Neural Nets

Caianiello's work in the area of the behavior of interconnected "yes-no" elements (abstract neurons) was originally inspired by the pioneering work of McCulloch and Pitts in the 1940's. Now, he finds it important to emphasize the essential nonlinearity that is fundamentally connected with Boolean algebra decision making, models of neural activity, and cellular automata. In order to unravel the enormous difficulties that arise in the long-term behavior and collective action of discretized, interconnected aggregates of yes-no decision elements, Caianiello broke down his program not into the customary, ever-to-be refined linear approximation approach of the whole, complex system and its dynamics, but rather, into the study of three distinct types of laws:

1. Neuronic equations (NE). These describe the behavior of the net with constant, fixed connections.
2. Evolution or mnemonic equations (ME). These should account for the change of the couplings among neurons which occur as a consequence of the activities described by the NE (thus, adaptation and learning belong in this field).
3. Adiabatic learning hypothesis (ALH). These studies should fix the respective time scales appropriate to the NE and to the ME and thus decouple the calculational work needed for NE and for ME (since their time-scales are believed to differ by a factor of  $10^6$ ).

Major progress has been recently achieved in area 1. In fact, a complete analytic solution of the NE has been obtained, and the general properties of the solutions have been analyzed (see Caianiello, 1986). The basic tools used for obtaining the solutions came from combinatorics. Caianiello also exhibited the close relation between the continuous and discrete aspects of the theory which, he believes, is essential for any concrete application of the formalism to adaptive learning devices, and also for reliable design of less ambitious AI systems. Finally, an interesting mathemati-

cal point was elucidated: it was shown that any Boolean function or net can be always reduced to a larger linear net. Thus, the consideration of Boolean nets cannot yield behavior that one cannot (at least in principle) obtain from sufficiently large linear nets.

These breakthrough results formed the starting point of the work by M. Marinaro and Caianiello (1986) where the inverse problem was exhibited and partially solved. The scientists showed that, given any preassigned sequence of states, it is possible to give an explicit, compact expression that determines formally which Boolean function must be assigned to each cell in order for the cellular automaton (or more generally, the neural net) thus constructed to go through this preassigned sequence in the prescribed order. The starting point of the mathematical approach leading to this result was the linearization of the dynamics by passing from a Boolean  $N$ -space to a linear functional  $2^N$  space: as pointed out above, this can be done rigorously.

Current work in this area is based on the observation that the mathematical methods so far used for NE studies permit, in principle, the exact formal synthesis of any cellular automaton whose behavior is prescribed a priori. One of the specific problems currently under study is: what can one say of an automaton in which each cell changes its state with a linear threshold logic? (Present results assure one that such an automaton cannot be "additive" because these correspond to nets of monomial nonseparable Boolean functions.) The Salerno scientists are convinced that such types of questions might be better studied analytically than by computer simulation--and I, personally, find this belief a refreshing alternative to current trends.

#### Composite Set Calculus

Composite set calculus--for short, C-calculus--is a new algebraic method developed by the Caianiello-school as a general technique for the analysis of complex hierarchical systems. In essence, it is a tool for dealing with situations in which increasing degrees of precision in measurement or in prediction are desired: an appropriate handling of less precise measurements by C-calculus can yield more precise measurements. Since "measurement" stands here for the most general meaning of the term, it should be expected that C-calculus may play an important role of information-handling that occurs in many areas of AI research, including pattern recognition.

A composite set (C-set) is defined as an ordered string  $A = (a_1, a_2, \dots, a_n)$



of arbitrary "elementary" sets that can be assigned some numerical value  $M(a_k)$  (or several such numerical values.) Two algebraic operations are then defined in the universe of C-sets. First:

1. Addition:

$A+B = (a_1 U b_1, \dots, a_n U b_n, \dots, a_n U b_1, \dots, a_n U b_n)$  where  $U$  means set-union and where the numerical value associated with set  $a_k U b_j$  is  $\max \{M(a_k), M(b_j)\}$ .

2. Multiplication:

$A \cdot B = (a_1 \cap b_1, \dots, a_n \cap b_n, \dots, a_n \cap b_1, \dots, a_n \cap b_n)$ , where  $\cap$  means set-intersection, and the numerical value associated with set  $a_k \cap b_j$  is  $\min \{M(a_k), M(b_j)\}$ .

I have oversimplified the calculus, assuming that there is only one value,  $M(a_k)$ , associated with each set, but this need not be so. In any case, it can be shown that the universe of C-sets equipped with the  $+$  and  $\cdot$  operation is a communicative semi-ring. The simplest example of the C-calculus is the following. Let  $A$  and  $B$  be two partitions of a line segment, and let the numerical value associated with the subsegments be their length. Then, the product of  $A$  and  $B$  is the partition of the given segment which is defined by using all "endpoints" of both the  $A$  and the  $B$  partition subsegments as new segmentation points. Clearly, the C-product of the two partitions gives a refinement of one by the other.

This property of C-products is precisely the one that can be used, for example, in automatic image analysis, particularly pattern recognition. One uses a pixel-network to cover an image and measures, for each pixel, the minimum and the maximum of, say, "grey levels." Then one slightly translates the pixel-network, goes through the same procedure--and takes the C-product. It can be shown that the latter will give information on the image that is more precise than either of the two component informations were. Caianiello and his associates have shown that, by suitable changes of pixel size and network-displacements (and number of displacements) one can arrange that C-calculus leads to filtering, or to contour extraction, or to image refinement, or to contraction/dilatation, or to texture analysis, and so on. In other words, C-calculus permits a *unified* methodology to different aspects of automatic analysis, which, in the standard approaches, are all achieved separately and by diverse "tricks."

Two recent articles on C-calculus can be found in Caianiello and Aizerman (1987).

## References

- Caianiello, E.R., "Neuronic Equations Revisited and Completely Solved," *Artificial Theory*, eds. G. Palm, and A. Aertsen, (Springer Verlag, 1986), 147-160.  
Caianiello, E.R., and M.A. Aizerman, eds., *Topics in the Integral Theory of Structure*, (Reidel Publishing Company, 1987), 163-173; 183-197.  
Marinaro, M., and E.R. Caianiello, *Physica Scripta*, 34 (1986), 444-448.

## Mechanics

### JOINT MEETING OF THE FRENCH AND ITALIAN COMBUSTION SOCIETIES

by Eugene F. Brown. Dr. Brown was the Liaison Scientist for Fluid Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office until September 1987. He has now returned to the Virginia Polytechnic Institute and State University, where he is a Professor of Mechanical Engineering.

The first joint meeting of the French and Italian Combustion Societies was held from 16 through 19 June 1987 in Amalfi, Italy. The presentations were grouped into nine topical areas:

- Pollutant Emissions Control
- Combustion Chemistry
- Stationary Combustion
- Soot Formation and Oxidation
- Engine Combustion
- Flame Propagation, Ignition, and Extinction
- Fluidized Bed Combustion
- Spray Characteristics and Combustion
- Coal Combustion.

A total of 109 papers were given in two concurrent sessions with the greatest number of papers coming from Italy (50) followed by France with 35, and the remaining papers contributed by Germany (11), England (5), US (4), Belgium (2), Poland (2), Portugal (1), and Hungary (1). A complete book of abstracts was distributed to each participant at the beginning of the meeting. A conference proceedings will not be published.

As is perhaps already obvious from the listing of session titles, the



variety of topics presented at this meeting was immense. The presentations varied in intellectual content from design exercises using commercial software and classical combustion and turbulence models to detailed studies of the fluid mechanics and chemistry of carefully controlled laboratory experiments. The interested reader will have no difficulty in discovering which of these presentations I found to be of the greatest interest. They will be described in the following paragraphs. What is less obvious is what I chose not to report, so let me make that clear here at the beginning. I will not be reporting on presentations which featured the chemical aspects of combustion (detailed reaction mechanisms and kinetics, for example), soot formation, pollutant emission, and coal combustion (including fluidized bed combustion). I have also excluded a number of design-oriented internal combustion engine studies in which detailed measurements (of velocity, and in some cases, temperature) inside the combustion chamber were reported. Finally, because this was the first joint meeting of the two societies, a number of papers of dubious quality were included for the legitimate purpose (in the context of this meeting) of presenting a complete picture of the research activities taking place in the two countries. These papers have also been excluded. Finally, from what remains, the reader will find that I have decided to report those presentations which have more than a casual connection with computational fluid dynamics (CFD). Obviously, this is because of my own technical interests.

A surprising and unintentional outcome of the selection process just described is that not a single Italian presentation is reported in this article. The reason is that the strength of the Italian combustion community, judging from the program and the sessions which I attended, lies in the experimental aspects of engine combustion, coal combustion, and fuel spray characterization and not in the CFD-related combustion research, which I have chosen to report on here.

#### The European Communities Combustion Research Program

P. Zegers, Program Manager of Energy Conservation R&D of the Commission of the European Communities (CEC) described the CEC combustion research program now underway in the European Economic Community (EEC). This program was undertaken in response to a European Community (EC)-sponsored survey of European combustion research and development activities carried out by the UK Atomic Energy Research

Establishment (AERE)-Harwell in 1985. The conclusions of this report were:

- The scientific and technical level of European research workers and of European research institutions was comparable to those found in the US and Japan.
- The level of funding was adequate in general (although slightly lower than the US and Japan) but unevenly distributed.
- The activity was fragmented and poorly coordinated, causing unnecessary overlaps and gaps.
- Communications between the scientific and industrial sectors was poor, causing slow diffusion of potentially useful results.

Consequently, in 1986 a 2-year European research program in combustion was initiated with \$9 million contributed by the EEC and an equal amount through cost-sharing provided by the various European industries and Joint Research Committee (JRC), which is a consortium of European automobile manufacturers including British Leyland, FIAT, Peugeot, Renault, Volkswagen, and Volvo. To address the lack of communication between the scientific and industrial sectors which was brought out in the Harwell study, all projects were designed to have both an academic and an applied character, and the sharing of information was assured by including the preparation of written reports and attendance at periodic contractors' meetings as "deliverables" in each contract. Fourteen separate contracts have been let under this program involving partnerships of 40 industrial, university, and government laboratories.

The first CEC project is being managed by Harwell. It is directed toward the basic aspect of turbulent combustion modeling, chemical kinetics, elementary combustion mechanisms, and advanced diagnostics. On the theoretical side, an extension of the "flamelet" model will be explored for highly turbulent combustion. On the experimental side, the modern diagnostic techniques of coherent anti-Stokes Raman spectroscopy (CARS) and laser-induced fluorescence (LIF) will be pursued for cases of high-pressure combustion. In the kinetics area a Kinetics Data Center will be established at the University of Leeds, UK, which will serve as a "clearing house" for new and already published data and be directly accessible by all universities and industries of the EC.

The second project is the development of global combustion models for optimizing the performance of reciprocating engines (both diesel and Otto cycle).

This project, managed by the JKC, will involve the development of a basic gas-flow code for reciprocating engines, a study of nonpremixed combustion and knock in spark-ignition engines, and the development and evaluation of a three-dimensional fuel spray model for reciprocating engines.

The third project, managed by Daimler-Benz and IVECO (the Italian commercial vehicle manufacturer), is directed toward improving the performance of spark-ignition (Otto cycle) engines by improving the combustion process during the initial phase of the power stroke and improving the performance of diesel engines by understanding a systematic experimental investigation of various factors on cycle performance such as the energy of the injected spray, swirl and turbulence induced by the intake, and the effect on turbulence caused by piston movement and combustion.

The fourth and last project, managed by Harwell and Lloyd's Register of Shipping, is to explore the use of low-speed flow data, especially in marine propulsion.

In addition to the results obtained to date, there is in the process of planning a 4-year follow-up program and believes that the results of the project will demonstrate the effectiveness of such a coordinated academic and industrial initiative and serve as a model for other cooperative research activities within the area.

#### Gas Turbine Combustion

B. Whitelaw of the Fluid Mechanics Section of the Department of Mechanical Engineering at Imperial College (UK) describes the activities undertaken over the past several years in his laboratory to obtain a better understanding of the behavior of gas turbine combustors. He discusses the use of laser Doppler anemometry (LDA) and digitally compensated, fine-wire thermocouples for making velocity and temperature measurements, and the special problems which limited accessibility and high temperatures produce. He went on to describe yet unanswered questions involving the interpretation of the fluctuating velocity and temperature measurements. For example, it is still very much an open question whether LDA measurements provide time-averaged or density-weighted velocities. Problems also arise in connection with concentration measurements, particularly if small, high-resolution, uncooled probes are used. This is because, without cooling, quenching reactions continue within the probe which contribute a substantial degree of uncertainty to the accuracy of the sample.

Despite these difficulties, Whitelaw believes that for the first time a reasonably complete understanding of the behavior of gas turbine combustors has been obtained. Among the most interesting results which Whitelaw found is that the level of turbulence intensity in a gas turbine combustor is much less than originally thought. For engines in which annular combustors employing a vaporizer are used (such as the Rolls-Royce Tay) turbulence intensities are always less than 18 percent. Finally, temperature-conditioned sampling of the velocity measurements has raised considerable doubt about the adequacy of conventional  $k-\epsilon$  turbulence modeling for gas turbine combustors. In particular, he has found that hot packets of fluid travel more slowly than cool ones do, which demonstrates that that transfer modeling based on the so-called gradient diffusion model must inevitably be in error. Moreover, a careful consideration of the terms required to produce an accurate calculation of the radial heat flux has convinced him of the importance of including the effect of the mean pressure gradient in the turbulence model, a factor which is not included, for example, in the  $k-\epsilon$  turbulence model. Unfortunately, current combustor designs seem to favor an increased amount of premixing, which appears to accentuate both the importance of including the effect of the mean pressure gradient and nongradient diffusion. For such situations, Whitelaw believes accurate calculations can only be obtained by solution of the Reynolds-stress and the related heat flux equations.

#### Combustion Simulation and Modeling

Regardless of how the chemical reactions are modeled, some way must be found to provide adequate spatial resolution of the flame fronts. B. Larrourou of Institut National de la Recherche en Informatique et en Automatique (INRIA)-Sophia Antipolis (France) presented his approach, which involves a moving mesh system which follows the flame front and which automatically adjusts its fineness to calculate the rapid variations in properties which are found there. The flame front is centered in the computational zone by moving the mesh forward at the local flame speed. The proper concentration of cell size (Larrourou uses a finite element computational algorithm) is achieved through a combination of dynamic and static rezoning. In recent work Larrourou has conditioned the static rezoning process by means of a mesh function which reflects the local "goodness" of the mesh. That is, it reflects the accuracy of the spatial approximation and the local mesh regularity. He showed

the boundary between the burned and unburned particles (the flame front) from the burned side into the unburned one with a prescribed laminar flame velocity. Both one-dimensional and two-dimensional (square lattice) simulations were carried out. The turbulent flame speed was determined from these results by calculating the mean value of the local flame speed over the entire flow field and averaging these results over 30 realizations. The flame thickness was obtained in the same way from the variance of the position of the flame front. What was found was a nearly linear variation of the turbulent flame speed with turbulence intensity. Its slope of 1.8 agreed well with a slope of 2, which is often cited from physical experiments. In addition, a linear relationship between the turbulent flame velocity and the integral length scale was found.

In separate papers E. Borghi (University of Rennes, France) described two very different approaches for handling the interaction between turbulence and combustion. The first of these two papers (presented by H. Nani) concerned the calculation of butane combustion in a model spark-ignition engine by means of his Interaction With the Mean (IEM) method. In these calculations the mean temperature and species concentrations were obtained from the KIVA code, a finite element code for general purpose internal combustion engine modeling developed by the Los Alamos Scientific Laboratory, New Mexico. The KIVA code, however, requires mean reaction rates. Borghi's IEM technique provides this information by means of Lagrangian balance equations for the fluctuating temperature and species concentrations and an assumed probability density function. Arrhenius-form reaction kinetics are employed in the chemistry model which is based on a complex hydrocarbon combustion model due to J. Warnatz. Encouraging results for the burned fraction of fuel and oxidizer and the mean pressure as a function of crank angle were obtained for a premixed-charge engine with a compression ratio of 10 and an equivalence ratio of 0.9, but no specific comparison with experimental data was shown.

The second paper was a very original contribution in which Borghi used the Cellular Automata (CA) approach to study turbulent wrinkled flame propagation. Purpose of this work was to explore whether the CA approach in conjunction with a simple combustion model and a random-walk turbulence simulation could produce a realistic variation of flame propagation velocity and flame thickness with turbulence intensity and turbulence length scale.

The simulation was carried out in three steps. In the first step, all fluid particles were displaced in accordance with a turbulence field of specified intensity by means of a random-walk procedure. The second step involved examining the particles at each site along with their nearest neighbors and coalescing the particles on the site (or populating the site if it is unfilled) in accordance with a simple set of interaction rules. The third step consisted of propagating

the boundary between the burned and unburned particles (the flame front) from the burned side into the unburned one with a prescribed laminar flame velocity. Both one-dimensional and two-dimensional (square lattice) simulations were carried out. The turbulent flame speed was determined from these results by calculating the mean value of the local flame speed over the entire flow field and averaging these results over 30 realizations. The flame thickness was obtained in the same way from the variance of the position of the flame front. What was found was a nearly linear variation of the turbulent flame speed with turbulence intensity. Its slope of 1.8 agreed well with a slope of 2, which is often cited from physical experiments. In addition, a linear relationship between the turbulent flame velocity and the integral length scale was found.

These numerical experiments are only a crude approximation of what happens in an actual turbulent flame, and only the effects of turbulence on combustion and not the reverse were included; however, the physical realism provided by the results is striking. Now that the basic model has been established, calculations for other cases are clearly possible (and have been done) for situations involving multiple scales and oblique flames. Although, from an engineering point of view, such calculations must be viewed as being fairly simplistic, the phenomenological understanding provided by such calculations can produce improved turbulence models which in turn can be used in the solution of more realistic problems.

#### Industrial Applications

An industrial furnace application was described by B. Viollet of Electricité de France (Paris). Separate consideration was given to the mixing of the flow and the combustion process using a zonal computation method which permitted the different scales present in the mixing and the combustion regions to be separately considered. To minimize the errors due to numerical dissipation, a bicharacteristic integration method due to Esposito (1981) was used. A one-step, single-reaction, fast-chemistry model due to Jones and Whitelaw (1982), and a probability density function approach using beta functions was employed in order to calculate the instantaneous mass reaction of fuel. In the calculations, a  $k-\epsilon$  turbulence model was used and a separate equation was written for the transport of the variance of the mixing rate. Radiation was accounted for by both a flux and a modified discrete transfer method. The high values of the mean temperature and turbulent temperature fluctuations in

preliminary calculations in an unconfined methane flame seemed to suggest that the constant used in modeling the dissipation of the variance of the mixing rate might be too large.

Computations of the oscillations in ram-jet combustion chambers were described by W. Sirignano of the University of California, Irvine. In liquid-fueled ram-jet combustors, combustion-driven oscillations are common and in fact may be taken advantage of to increase the combustion efficiency. To take advantage of such oscillations when they are desired and to prevent them when they are not, it is important to identify the rate-controlling combustion mechanism associated with their presence. Sirignano believes that these mechanisms are vaporization and droplet heating--despite the failure of previous attempts to demonstrate this. Sirignano attributes this failure to the assumptions of either temporally constant or spatially constant droplet temperatures. Sirignano's calculations sponsored by the Office of Naval Research assume neither and, in fact, allow for internal circulation and liquid convective heating within the fuel droplet. He undertook a one-dimensional unsteady calculation of the flow within a liquid-fueled ram-jet combustor in which the mechanism for gas-phase oscillation on the droplet heating and vaporization rates was included. A fully coupled case was considered in which an Eulerian approach was used for the gas phase and a Lagrangian approach for the liquid phase. The flow at the inlet of the combustor was pulsed by a single-cycle sinusoidal oscillation, and the resulting behavior of the flow was observed. Unlike previous attempts, including the temporal and spatial uncertainties in the droplet temperature permitted Sirignano to demonstrate sustained (rather than decaying) oscillations of inlet gas velocity and inlet air pressure in response to this pulse. These calculations indicated that vaporization control is a liquid-fueled combustor, and not one mechanism for combustion instability.

Development of an aviation-type gas turbine engine for the Module d'Energie Sub-Marine Autonome (MESMA), a small submarine for oceanographic and offshore use, was described by J.P. Grousset of Aerospatiale-Matras-Verdun (France). The Ramjet-type propulsion system was designed to supply 40 kW using either toluene or a kerosene mixture as the working fluid. The combustor which operates on methane and oxygen at a pressure of 60 bar, is particularly interesting. Such high pressures are required in order to increase the power density of the combustor and to permit the  $\text{CO}_2$  produced in the

combustion process to be liquified at the temperature of the seawater and stored on-board the submarine. On-board storage of the combustion products is important in order to avoid the tendency of the submarine to rise as the fuel is consumed. The combustor is 62 mm in diameter and 132 mm long, giving it a power density of approximately 20 MW/m<sup>3</sup>/atm.

Considering the extremely high pressure, the design of the combustor appears to be surprisingly conventional with an array of film-cooling slots and primary air holes around the periphery, a swirl-stabilized injector, and a ring of downstream dilution holes. The design exit temperature is 900°C with cooling of the walls provided by the recirculation of the cooled combustion products. Ignition is by means of a plasma jet, and flame control is provided by a photocell. The design of the combustor was carried out by means of a synergistic combination of a number of in-house and commercial codes which are shown in schematic form in Figure 1.

One of the greatest uncertainties is the character of the spray which will be formed by the methanol injectors at such elevated pressures. To obtain such data a series of tests are being planned at the University of Rouen (France). A 12-month series of low-pressure combustion tests are planned in which wall temperature, gas analysis, pressure drop, and droplet size and population density measurements will be made. This work is partially funded by EEC.

#### Experimental Investigations

Three combustion experiments were of a sufficiently fundamental nature to warrant reporting here. The first of the experiments was carried out by D. Escudié at the Ecole Centrale de Lyon (France). The motivation for the experiment was to obtain fundamental understanding of the interaction between the flow field and combustion in a simple physical configuration. The experiment consisted of a lean, premixed, laminar hydrogen flame stabilized by a 0.4-mm-diameter platinum wire. The flame was surrounded by a 114-mm-diameter Pyrex tube in which small circular rods of 0.4-mm and 1.0-mm diameter could be mounted at various distances upstream of the flame (see Figure 2).

Measurements were made both with laser Doppler anemometry (for which the flow was seeded with aluminum silicate particles) and with laser tomography in which the flame was visualized by the smoke of burning incense. The phenomenon of interest was interaction between the Kármán vortex street shed from the circular cylinder and the flame. The small

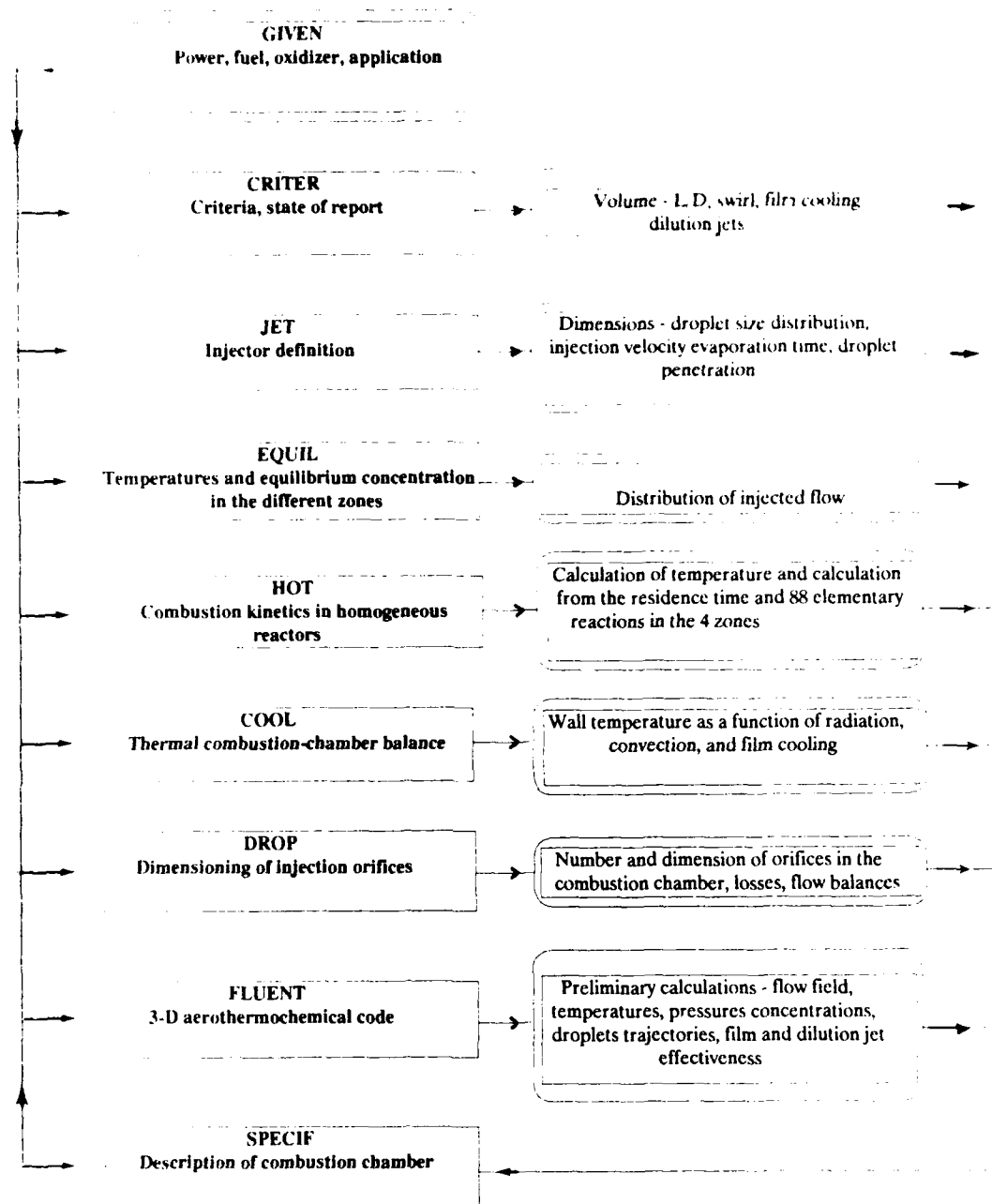


Figure 1. MESMA design strategy.

cylinder produced a laminar Kármán vortex street. Its effect was to produce a wrinkled flame front in which the wavelength was well defined and equal to that of the vortex street. The amplitude of the wrinkling first increases and decreases, possibly due to the density reductions of

the flame front, until the amplitude of the wrinkles become approximately equal to the width of the vortex street. Further downstream, the amplitude of the wrinkling decreases again and eventually disappears as the vortex street is consumed by the combustion process.

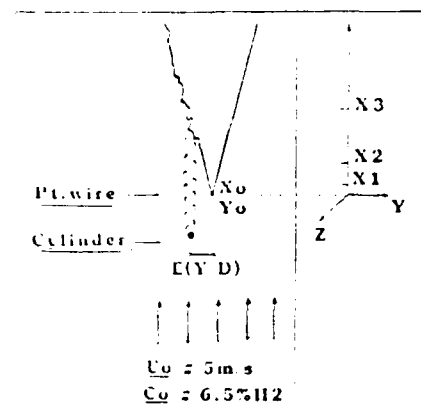


Figure 2. Vortex-flame interaction experiment.

The larger diameter wire, when elastically mounted and allowed to vibrate in response to the aerodynamic forces by the shed vortices, again produced a laminar vortex street but with greater amplitude and strength. Like the previous case, a regular wrinkling pattern appears along the flame front; however, the increased strength of the vortex street seems to carry the flame away with it. In the third case, the larger rod was held in a fixed position, and a turbulent vortex street was produced. Here the perturbations are of larger scale than the flame-front thickness and both sides of the flame are affected by the presence of the cylinder. On the side of the flame facing the cylinder, the high intensity of the vortex street produces a sufficiently intense shear that the flame is stretched, perhaps to the extent of local extinction. On the other side of the flame a regular disturbance is seen.

Another interesting fundamental experiment was described by B. Deshaies of the Ecole Nationale Supérieure de Mécanique et d'Aérotechnique (Poitiers, France). The objective was to confirm the influence of stretch and curvature on the laminar burning velocity in premixed flames which is suggested by the theory of Clavin and Joulin (1983). For axisymmetric flows, the theory predicts a linear dependence of the nondimensional flame speed on the curvature of the flame and on the velocity gradient in the fresh mixture at the flame front. The experimental setup which was used to verify this relationship consisted of a vertically oriented "flat flame" burner which contained a sufficient number of damping screens and honeycombs that an axisymmetric laminar flow was produced. The reactive mixture consisted of a lean (0.80 equivalence ratio) air/propane mixture in which the flame was stabilized

by a flat stagnation surface on which it was assumed that adiabatic conditions existed. By varying the velocity profile at the burner exit, various flame shapes could be produced from a classical flat flame to an inverted curved flame with the center of curvature located in the burned gases. The velocity gradient and the flame-front curvature were measured with LDA and laser tomography, respectively. In both cases, the flow was seeded with small oil droplets. Since the temperature of the flame front far exceeded the boiling point of the oil, it was impossible to measure the velocity gradient at the flame front itself and therefore an extrapolation procedure was worked out using an approximate flame-front evolution model. Despite this shortcoming, it was concluded that the data verified the expected linear dependencies on curvature and velocity gradient to within a few percent. Further experiments are underway in which seeding by submicron-size solid refractory particles will be used to obtain an improved measurement of the velocity gradient at the flame front. In addition, stronger amounts of curvature (both positive and negative) will be investigated to further explore the limits of the theory.

The objective of the work presented by S. Zikikout of the Ecole Centrale de Paris was to examine the extinction of turbulent non-premixed flames by low-frequency self-induced oscillations. The geometry consisted of a 300-mm-long, 50-mm-wide, 100-mm-high glass-walled combustion chamber fed by three pairs of propane injectors (see Figure 3). Propane injectors consist of six spanwise slots mounted in pairs around which the air passes into the combustion chamber from a 3.8-m-long duct upstream of the injectors. In the experiments, the equivalence ratio was varied between 0.2 and 1.2 and the air flow was varied between 6 and 24 gms per second. The instrumentation

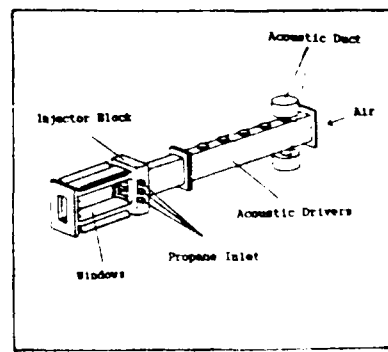


Figure 3. Self-induced combustion instability.

consisted of microphones located both inside and outside the combustion chamber, a photomultiplier tube equipped with an appropriate filter for spectral measurement of free radical (C or OH) emission and a schlieren flow-visualization system. Spectral analysis of the acoustic signals revealed the existence of acoustic oscillations at 224 and 340 Hz at which C<sub>2</sub> emission studies indicated that either the partial or total extinction of the flame occurred. An examination of the power spectral density of the acoustic signal revealed that the oscillations were strongest at 340 Hz and is thought to result from instabilities produced by the interactions between the flames. The oscillation at the lower frequency is less intense and corresponds to the low-frequency cyclic combustion resulting from an interaction between the heat release mechanism and the acoustic field. Under conditions where the oscillations are most intense, discrete structures can be identified in the schlieren photographs.

#### CONCLUSIONS

From the intensity of the discussion which took place during and after the technical presentations, it was clear that the objective of sharing information on combustion research programs in France and Italy was well met during this meeting. The meeting provided a forum in which the need for collaborative activities between the two countries could be explored. The CEC's combustion program, which at this meeting provides a mechanism by which such research can be supported.

#### REFERENCES

1. V. J. B. and G. Joulin, *Journal de Physique* (1983), 44: L1-L12.
2. J. L. B. P., "Resolution bidimensionnelle des équations de transport par la méthode des caractéristiques," *Rev. Phys. Appl.* (1981), 41/81.16.
3. J. L. B. P. and J. H. Whitlaw, "Calculation of the structure of reacting turbulent flames: a review," *Combustion and Flame*, 46 (1981), 1-26.

#### INTERNATIONAL JOINT WORKSHOP ON TURBULENT REACTIVE FLOWS

July 6-10, 1987, Rouen, France

A United States-France Joint Workshop on Turbulent Reactive Flows was held

in Rouen, France, from 6 through 10 July 1987 to discuss current activities taking place in turbulent reactive flows in the US and France and to explore opportunities for collaborative research between the two countries. The meeting was jointly sponsored by the US National Science Foundation and the French Centre National de la Recherche Scientifique and was organized by Professor R. Borghi of the University of Rouen and Professor S.N.B. Murthy of Purdue University. Attendance was by invitation only and restricted to those people actively involved in turbulent reacting flow research in the two countries, plus ONRL-sponsored observers from Spain, Germany, and the UK. Forty-seven presentations were made during 3-day meeting. Most of the papers were distributed in advance of the meeting and it is anticipated that a complete proceedings will be published by Springer-Verlag in their *Lecture Series in Engineering*.

Sessions were organized on the following topics:

- Structure of turbulent flames
- Measurements
- Supersonic combustion
- Numerical methods.

In the following paragraphs I will concentrate on the French contributions to these sessions. Contributions from countries other than France will be specifically noted.

#### Flame Structure Theory

In a joint paper, P. Clavin (Université de Provence, Marseille) and G. Joulin (Université de Poitiers) described their recent studies of the structure and propagation of wrinkled flames. Joulin said that there were really two approaches to studying flame structure. One is to study special configurations (such as planar flames or stagnation flows) in which the theoretical analysis of the problem is simplified by concentrating on presence of only a single effect (high strain rate, for example). The other approach is to study general configurations (such as wrinkled flames) but to allow only small values of strain, curvature, etc. to be present with the hope of carrying out the analysis by means of small-perturbation methods. Their work, in which highly corrugated flames were examined in order to study the effects of weak strain, curvature, and heat release, is an example of the second approach.

By expressing the burning velocity as a small perturbation on the laminar flame speed, Joulin examined the influence of the curvature tensor and the velocity field and excluded various terms

on the basis of order of magnitude estimates and physical reasoning. Eventually, he was able to express the burning rate in terms of the laminar flame speed and perturbations involving the local radius of curvature of the flame front and a rate of strain tensor value at the flame front. Joulin insisted that care must be exercised in allowing for local geometric and kinematic conditions in writing the jump relationships for wrinkled flames. Solving for the topology of the flame front is an extremely difficult hydrodynamical free-boundary problem. However, it can be shown that the wave length of the so-called Darrius-Landau instability in laminar flames is selected from the high-frequency, small-scale turbulence in the oncoming flow and that the low-frequency, large-scale turbulence in the oncoming flow is responsible for the intermittency of the flapping flame front.

The matter of whether or not laminar flamelets have a fractal dimension was the topic of the paper by F.C. Gouldin (Cornell University, Ithaca, New York). The determination of fractal dimension is rather like coherent structures in that different individuals see different things. This situation is complicated by the fact that the experiments upon which these determinations are based usually consist of relatively small samples; the situation is further complicated by the fact that the extent of the inertial subrange is rather limited due to the small Reynolds numbers which characterize these tests. P.E. Dimotakis of the California Institute of Technology (Pasadena) insisted that the flames which he has investigated have no fractal dimension. P. Clavin (Université de Provence, Marseille) added that in calculations which he had done of a cellular flame (by means of a lattice gas model) he was unable to find a fractal characterization of the flame, either. N. Peters, Rheinisch-Westfälischen Technischen Hochschule Aachen (West Germany), added that the fractal conjecture of turbulent flames may or may not be true; however, the concept provides a nice way of thinking about the relationship between turbulence and laminar flame speed (in terms of the fractal area of the flame front).

Professor A. Liñan (Universidad Politécnica de Madrid, Spain) presented his work on diffusion flame attachment. He seems to have made some progress recently in conceptualizing the mathematical character of the flame attachment process and in unravelling some of the mathematical dependencies within the problem. He distributed a complete set of notes which summarized his current understanding of the problem; I would be

happy to distribute them to anyone having an interest in this work.

#### Flame Structure Experiments

D. Escudie (Ecole Centrale de Lyon) described her study of the structure of a laminar flame front interacting with vortices generated by an upstream rod. An interesting new aspect of her work is the investigation of the interaction of a single vortex (rather than a vortex street) with a flame. As possible means for generating such a vortex she has been experimenting with a thin baffle plate and an aspirated circular cylinder. In the latter case the rate of acceleration of the baffle plate provides control over the vortex strength.

The paper by Ph. Goix (Université de Rouen) was much in the same spirit as that presented by Escudie. In this case, however, the flow was turbulent and what was of interest was not the influence on the flame of the vortices produced by a single upstream rod, but rather the effect on the flame of the vortices produced by an upstream grid. I had seen some of this work during my visit to Rouen in May of this year (ESN 41-4:213-215 [1987]). Laser Doppler anemometry and laser tomography were used to measure the effect of the grid-generated turbulence on the mean and turbulence velocities and flame front structure of a lean, V-shaped, turbulent, hydrogen-air flame. The experiments were carried out for both an unconfined flame and cases where negative pressure gradients of 40 Pa/m and 72 Pa/m were maintained. Close to the flame holder, a strong reduction of the velocity fluctuations is observed within the flame, resulting from an increase in the dissipative terms due to the temperature increase within the flame. Far downstream, a strong increase of the axial component of turbulence velocity is observed. This effect is accentuated by the mean pressure gradient and is nonexistent for the unconfined (zero pressure gradient) case. The pressure gradient also has the effect of increasing the value of the Reynolds stress.

In the spirit of turbulence/flame interaction, but not as yet involving combustion, was the work of J.N. Gence (Lab oratoire de Mécanique des Fluides, Ecole Centrale de Lyon). It concerned the measurement of the decay of concentration fluctuations of a fluorescent dye injected downstream of a grid in a water channel. In a combustion context one could think of the dye, which was injected through holes drilled into the nodes of the grid, as being the fuel and the water as being the oxidizer. The decay of the concentration fluctuations of the dye is a direct measure of the



mixing ability of the flow field. Concentration measurements are much more difficult in water than they are in air because the small molecular diffusivity of water produces dissipative scales that are two orders of magnitude smaller than those found in air. The classical technique for making such measurements is to use a conductivity probe, but in preliminary experiments Gence discovered that even the smallest conductivity probe was too large to resolve the spatial and temporal turbulence scales which were present. Using laser-induced fluorescence (LIF) circumvented these problems. The test section downstream of the grid was illuminated with an argon ion laser and the amount of radiation absorbed by the dye (rhodamine B) was measured by a photomultiplier tube masked by a 100- $\mu$ m-diameter pin hole. Simple arguments can be used to show that the amount of radiation absorbed is proportional to the local concentration of the dye and is thus a measure of the amount of mixing which has taken place. The experiments were carried out in a 1-m-long test section of a 7.7-cm<sup>2</sup> water channel at a velocity of 0.5 m/s. The Taylor microscale 60 cm downstream of the grid consisting of 2-mm rods arranged in a square 6-mm mesh was found to be 120  $\mu$ m. The resolution of the concentration measurements obtained with LIF was 100 times that obtained with the conductivity pulse.

Gence's future plans include reducing the optical size of the probe volume (perhaps 30  $\mu$ m is the practical limit), to use two fluorescent dyes so that the concentration fluctuations in both "fuel" and "oxidizer" can be measured simultaneously, and eventually to use reacting fluorescent dyes so that the initial stages of a chemically reacting flow can be simulated.

Unperturbed flame structure was the topic of D. Stepowski (Université de Rouen). He considered a turbulent hydrogen-air diffusion flame in which instantaneous radial profiles of OH fluorescence and Rayleigh scattering were obtained. The flame had a vertical orientation and was produced by a central jet of nitrogen-diluted hydrogen surrounded by a coflowing stream of air. The fuel pipe was 1 cm in diameter and was fed with a 50-percent (by volume) mixture of hydrogen and nitrogen. The fuel jet velocity was 16 m/s. The coflowing air stream was provided by a 10-cm-diameter coaxial pipe. The air stream velocity was 10 m/s. A simple energy equation was used to calculate the maximum heat release using the peak temperature second derivative of the temperature profile (obtained from the Rayleigh scattering measurements). The surprising result of the experiments was

that temperatures far below the limits given for the maintenance of a steady diffusion flame under maximum strain conditions were measured. These low temperatures were attributed to intermittent extinctions due to turbulent stretching.

T.A. Baritaud of the Institut Français du Pétrole (Rueil-Malmaison) investigated the structure of the flame produced in an experimental engine running with a lean propane-air mixture. The engine was a single-cylinder production engine with a compression ratio of 6 and an 86-mm bore. Optical access for the schlieren flow visualization was provided both horizontally through windows provided in the side of the cylinder and vertically by means of a transparent piston and mirrored cylinder head. From the surface of the flame front obtained from the schlieren photos an equivalent burnt kernel radius was obtained; and, since a measure of time was provided by the rotational speed of the engine, the evolution of this burnt kernel radius as a function of time could be obtained. What was found was that the flame front was always turbulent and that the flame speed (the slope of the burnt kernel radius-time curve) increased with increasing engine speed. This contrasts with previous conjectures in which it was postulated that the flame propagated laminarily and independent of engine speed. It was found that as the engine speed was increased the higher turbulence levels produced an increased amount of wrinkling and the minimum size of the wrinkles decreased. An interesting feature of the experiments is that with increasing kernel radius the flame velocity first decreases and then increases again. This phenomena is not completely understood. Baritaud hoped that his data will lead to improved combustion models for spark-ignition engines. Such models he emphasized must account for the flame ignition, propagation, and wall-dominated combustion regimes. It turns out the wall-dominated combustion regime (where the flame front is less than 1 cm from the cylinder walls) accounts for more than 65 percent of the combustion process.

The paper by E. Esposito (Ecole Centrale de Paris) was the last presentation on this topic. It concerned an exhaustive set of experiments conducted to study premixed combustion instability mechanisms present in a multiflame, bluff-body-stabilized, rectangular combustor. Of particular interest was the obtaining of an understanding of the coupling between the combustor acoustics and the combustion process. The fuel used was propane, which was admitted to the 100x100 mm<sup>2</sup>, 200-mm-long combustor past six backward-facing steps which served as

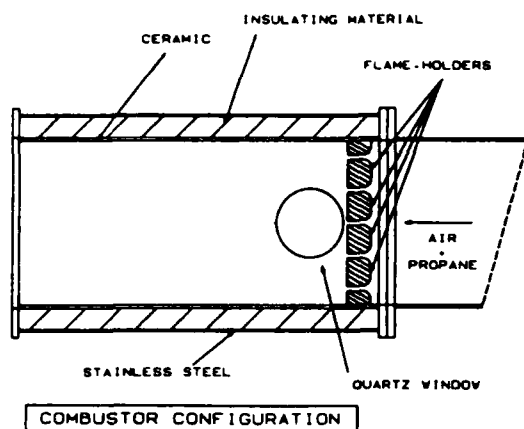


Figure 1. Combustor for investigating instability mechanisms.

flame stabilizers. Figure 1 is a schematic representation of the combustor tested. The instrumentation consisted of a spark schlieren apparatus, a  $C_2$ -emission system for measuring the instantaneous local heat release, and a microphone, which provided a reference signal for phase-average imaging. Both self-excited and externally excited instability mechanisms were investigated.

In the first series of tests, phase-averaged digitized images of the local heat release patterns in the duct were compared with the simultaneous schlieren visualizations and the pressure signals returned by the upstream microphone to investigate the structure of self-excited combustion instability and the nature of the feedback mechanism. The instability mode of interest was the principal longitudinal acoustic mode of the combustor and corresponded to a frequency of 530 Hz. In the results presented in Esposito's paper this condition was reached at an inlet jet velocity of 40 m/s and an equivalence ratio of 0.92. The schlieren photographs revealed large vortical structures which were shed at the flame holders in response to pressure waves received from a region of intense combustion located approximately 10 jet-widths downstream. This vortex proceeded downstream along the jet, growing in magnitude and eventually terminating in a mushroom-shaped cap. As adjacent caps merged and left the combustor they left behind them a region of high turbulence intensity in which intense combustion took place, resulting in a pressure pulse which propagated upstream and provoked the vortex shedding at the flame holders, thus reinitiating the process just described and completing the feedback mechanism. A subsequent examination of the

microphone signals revealed that the pressure pulses were in quadrature with the global heat release which, according to Rayleigh's criterion, is a requirement for self-sustained acoustic oscillations.

In the tests in which external acoustic excitation was used, the driver was adjusted to the frequency of the hydrodynamic mode of the jets. This produced a strong low-frequency, sinuous flapping of the jet accompanied by small vortices generated at the excitation frequency. The low-frequency-induced flapping motion of the jets made it impossible to use the phase-average imaging method used in the previous test since the flapping is the result of the superposition of many different modes. Instead, Esposito used a spectral processing technique from which frequency-filtered maps of the local intensity gradient and local instantaneous heat release fields were obtained. Simultaneous measurements of combustion intensity and local density gradients were made by  $C_2$  emission and the deviation of a laser beam (see Figure 2). The data appeared to be relatively new, and little interpretation of the results was reported.

#### Supersonic Combustion

The National Aerospace Plane (NASP) and the HERMES projects have rekindled interest, both in the US and in Europe, in the problems of hypersonic flight. In contrast to the AGARD hypersonics meeting (ESN 41-8:430-437 [1987]) which concerned itself, primarily, with the external aerodynamics of hypersonic vehicles, this session was concerned with the propulsion aspects. In an air-breathing vehicle, such as the NASP, it is generally accepted that combustion processes will have to be carried out at supersonic velocities with respect to the vehicle.

#### OPTICAL ARRANGEMENT FOR SPECTRAL MAPS SIMULTANEOUS MEASUREMENTS OF $C_2$ -RADICAL EMISSION AND LASER DEVIATION

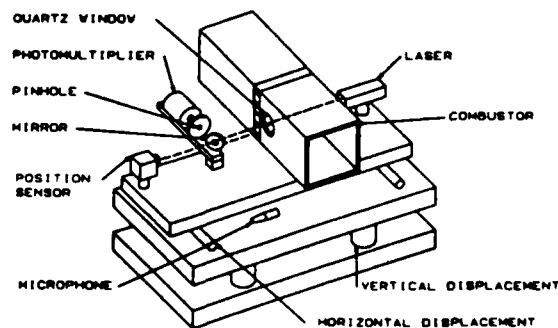


Figure 2. Simultaneous combustion intensity and density gradient measurements.

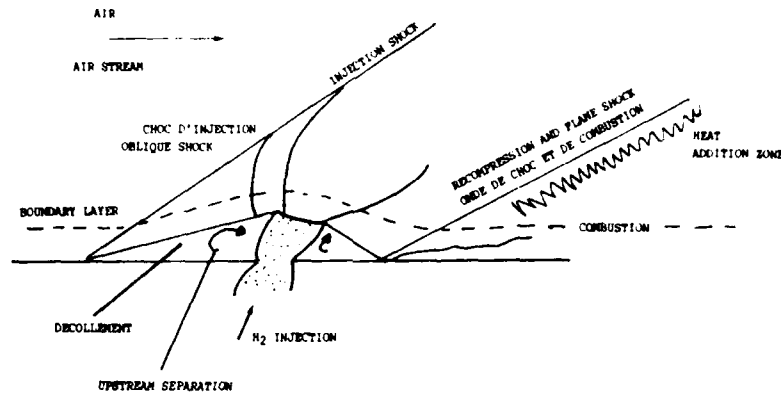


Figure 3. Wall injection into a supersonic free stream.

Professor J. Swithenbank (University of Sheffield, UK), in a paper which reviewed various aspects of hypersonic air-breathing engine design, pointed out that high engine performance and good combustion efficiency can be conflicting requirements. This is because high combustion efficiency requires good mixing, which requires high turbulence, which reduces the kinetic energy of the flow, which reduces the engine performance. Practical methods for producing the required amount of turbulence often serve the dual role of providing flame stabilization. It is important that the losses associated with the operation of such devices be minimized. Swithenbank, whose experience in this field goes back to the mid-1960's, feels that the double comb injector has much to offer in this connection and has proposed to the AFOSR a refurbishment of his Mach 3.5 combustion-driven hypersonic shock tunnel to verify this and other aspects of supersonic combustor design. It appears that he intends to use his new multipoint laser anemometry technique (FSN 40-5:165-169 [1986]) to provide flow diagnostics in connection with these tests. He also suggested that the FLUENT code to which he has recently contributed swirling flow models, could (with modification) be profitably used to provide numerical simulations of such flows.

Further discussion of means for achieving flame stabilization in a supersonic flow was provided by M. Barrere of the Office National d'Etudes et de Recherches Aérospatiales (ONERA), Paris. Barrere was in charge of ONERA's supersonic ramjet (scramjet) program until lack of funding brought it to a halt in 1974. The proposed first and second generation European earth orbiter projects (HERMES and Sanger) employ rocket propulsion systems and thus, Barrier said, unlike the situation in the US there is

little prospect of a supersonic combustion research revival in France. His presentation was, therefore, very much in the form of an historical review, indicating in particular what sort of fuel injection and flame stabilization techniques had been investigated at ONERA in the 1960's and early 1970's. For additional information about French supersonic combustion activities during this period see ESN 41-1:15-20 [1987].

Barrier pointed out that, in general, those injector designs which offer the smallest loss are those which present the greatest problems in terms of controlling the levels of wall heat transfer and achieving the necessary degree of flame stabilization. In addition to Swithenbank's comb injector, he mentioned wall injection (see Figure 3), wall injection with steps, strut injection, and subsonic pilot-flame stabilization.

The paper by Professor F.E. Marble (California Institute of Technology, Pasadena) presented a new concept for producing enhanced mixing of a fuel jet in a supersonic airstream. It involves passing the fuel jet (gaseous hydrogen, for example) through an oblique shock set up by, say, a skewed wedge placed along the bottom wall of the combustion chamber. An axially injected fuel jet in passing through the shock wave would have induced within it regions of intense vorticity due to the interaction between the density difference between the fuel jet and the air stream and the pressure field set up by the shock wave in accordance with the (Bjerknes theorem). Experiments have already been conducted to demonstrate the intense mixing which can be produced from this effect, and additional experiments have been proposed (with AFOSR support) in which the degree of molecular mixing will be measured by means of biacetal fluorescent dye. The second phase of the experiments will be concerned with the

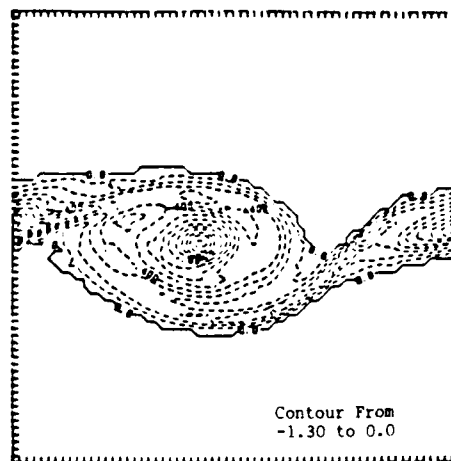
details of combustion within the vortical regions produced by the new mixing scheme. These will be carried out in an unsteady combustion facility in which the vortices will be produced at the lip of a downstream-facing step by acoustic excitation. In addition, it is proposed to continue the effort to obtain a numerical simulation of the shock-wave/fuel-jet interaction phenomena with a flux-corrected transport (FCT) code originally developed at the Naval Research Laboratory.

#### Numerical Methods

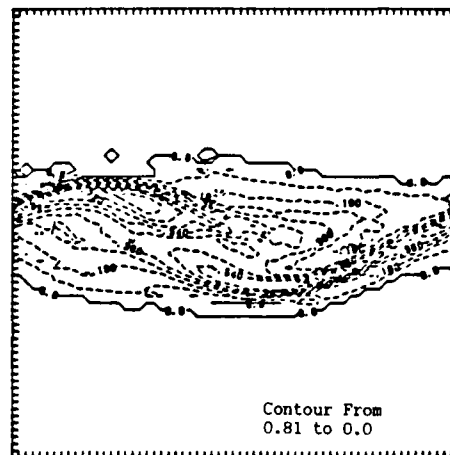
A wide variety of methods for computing turbulent reacting flows was presented at the meeting. Unlike theoretical and experimental areas where the French and US efforts appeared to be of roughly equivalent level and sophistication, in the computational area, particularly in the use of full Navier-Stokes calculations for simulating reacting flows, there seems to be evidence of considerably more activity in the US than in France. Typical of the US efforts in this area were the presentations by J.J. Ryley (University of Washington, Seattle) and J.C. Hill (Iowa State University, Ames).

Ryley's calculations concerned the effects of heat release and large-scale turbulence structures in a chemically reacting mixing layer using direct numerical simulation. Figure 4 is an example of the results obtained where the vortical structures and the mixing layer have been visualized by computed iso-vorticity contours. Figure 4a shows the topology of the spanwise vorticity component without combustion and Figure 4b, the same structure with combustion. The effect of the heat release is clearly to increase the scale of the vortex and to regularize its structure. Accompanying this regularization is a loss of fine-scale structure and an increase in the overall effective mixing length. This reduces the extent of the chemical reaction (decreases the amount of product formed), and decreases the rate of mixing layer growth. By examining the magnitude of terms involved in the Favre-averaged transport equation for turbulent kinetic energy, Ryley concluded that the reductions in the mixing layer growth and amount of product formed could be explained by the effect which combustion has on the thermal expansion and baroclinic torque terms and through these terms on the dynamics of the vorticities in the mixing layer.

The direct numerical simulations by J.C. Hill served a different purpose, namely to examine the accuracy of various simple, single-point closure theories for the modeling of irreversible, second-order chemical reactions of initially un-



(a) Without combustion



(b) With combustion

Figure 4. Spanwise vorticity components in mixing layer at a Reynolds number of 500.

mixed reactants. For this purpose a chemical reaction was simulated in a homogeneous turbulent field using a pseudo-spectral calculation, and the results were compared with the predictions obtained from the closure theories for such quantities as reactant concentration and the evolution of average scalar-fluctuation dissipation.

As previously mentioned, the French contributions to the calculation of turbulent reacting flows were of a far less computationally intensive nature than those of the US. The presentations featured the use of flamelet (coherent flame) models in conjunction with conventional flow field modeling techniques, the use of cellular automata (lattice

gas) simulations, and the application of state-of-the-art turbulence and combustion models to calculate the flow fields in gas turbine combustors and industrial burners. An example was the work of N. Darabiha (Ecole Centrale de Paris), who calculated the flow in a V-gutter-stabilized ramjet combustor by means of the coherent flamelet model and the  $k-\epsilon$  turbulence model. He found that his calculation of the spatial distributions of fuel consumption rate and temperature agreed in a qualitative way with the experimental spatial distributions of  $C_2$  emission and that the proper qualitative behavior of the flow field in response to changes in the equivalence ratio were also properly simulated. Although no quantitative comparison with the experiments was presented, Darabiha concluded that a reasonable correspondence between the computed and measured flow fields had been produced and that the foundation had been laid upon which to build further studies of the effect of various model refinements and improvements.

R. Borghi (Université de Rouen) reviewed various methods for turbulent reaction rate modeling beginning with the venerable eddy-breakup model and ending with his recently developed interaction with the mean (IEM) model. He went on to describe his recent work on simulating turbulent reacting flows with the lattice gas model. By considering separate steps in which the turbulence was simulated by a random walk process, followed by a particle interaction step, and finally a flame propagation step, Borghi was able to compute a mean reaction rate and to examine the influence of various time scales on the combustion process. In particular, he was able to determine a functional relationship for the ratio of the time scale of the progress variable to the turbulent time scale which depended upon the ratio of the turbulence fluctuations to the laminar flame speed. Obviously, such relationships are of great value and interest; however, everything hinges on the appropriateness of the lattice gas model for the actual combustion process. Much needs to be done to confirm the adequacy of such modeling, and Borghi is currently in the process of introducing a spatial-velocity correlation to improve the turbulence simulation employed in his calculations.

Examples of the application of more or less conventional turbulence and combustion modeling to industrial flows were provided by M. Dessaulty (SNECMA) and M. Simonin of Electricité de France. Dessaulty's calculations involved the prediction of the flow field in a dump combustor, a dome-type gas turbine combustor, and an afterburner using the  $k-\epsilon$

turbulence model and both finite volume and finite element methods. The application of these codes is the design of practical gas turbine combustors. Extensive verification of these codes has been made with laser Doppler anemometry (LDA) and coherent anti-Stokes Raman spectroscopy (CARS).

A far more complicated situation from a phenomenological point of view was considered by Simonin, who reported on his calculations involving the numerical modeling of the devolatilization of pulverized coal injected inside a hot co-flowing airstream. The calculations were spatially two-dimensional and contained separate conservation equations for both the particulate (coal particle) and continuous (air) phases including interface heat transfer terms and the effect of turbulence by means of a  $q^2-\epsilon$  turbulence model. In order to investigate the influence of particle size and temperature of the co-flowing air stream on the global rate of devolatilization, additional models were needed for the pyrolysis of the coal particles and the combustion of volatile matter. The intention of the calculations was to model the flow found in the burners of large powerplant furnaces. It is not surprisingly that the empiricism contained in such models produced calculations which were at best only qualitatively satisfactory. In fact, no concerted attempt was made to produce truly predictive calculations at this stage. Instead, the emphasis was on providing an understanding of the interrelationships between the various mechanisms involved in this very complex combustion process, on setting the stage for further refinements in the modeling, and on eventual validation with experimental data.

### Conclusions

Spirited discussion followed the presentations by virtually every speaker, and there were numerous conversations taking place between the French and US participants throughout the meeting. Thus there was evidence that the meeting provided an effective stimulant to the collaborative activities already existing between the two countries. The attainment of the objective of the meeting, namely to encourage the submission of collaborative proposals for joint French/US research in turbulent reacting flows, remains, of course, to be seen.

4/18/87

## FLUID MECHANICS RESEARCH AT THE UNIVERSITY OF NAPLES

by J. J. Luchini

Fluid mechanics research at the University of Naples is found in the Institute of Gas Dynamics, the Department of Mechanical Engineering for Energetics, and the Institute of Aerodynamics. The University of Naples is an ancient institution dating from the early 13th century, and its Faculty of Engineering, founded in 1916, is the oldest in Italy. It has 20,000 students (15,000 in engineering) and is the university, after the University of Rome, the second largest university in Southern Italy.

Several of the faculty members with whom I spoke had close connections with the US, either having received their education from US institutions or frequently visiting the US for various lengths of time for the purpose of carrying out collaborative research projects. The international connections of the faculty were further strengthened by availability of computer links through an IBM network connecting computer centers in the US.

I was struck by the diversity of fluid mechanics problems being worked on at the university. During the course of my visit, I discussed fluid mechanics problems ranging from hemofiltration to analytical methods for predicting automobile drag to numerical methods for avoiding fouling in heat exchangers to the computational properties of various formulations of the Navier-Stokes equations. Due to space limitations will enable me to report in depth on only a few of these topics. In most cases I was given the impression that I discuss here that I have a special interest in any of the topics mentioned please let me know and I will send you copies of the relevant publications.

### Organizational Structure

There seemed to be a major upheaval in the organization of the Faculty of Engineering at Naples. A recent Italian law given to the newly-formed engineering departments considerably more autonomy than to the older engineering institutes. This means that the head of a department can, by signature, authorize expenditures which, for the time being, would require the director of an institute to journey 6 miles through frantic and often grid-locked Neapolitan traffic. Some sort of reform seemed to be desperately needed with regard to scientific equipment placing a substantial surcharge on all equipment purchased in order to compensate for the

considerable delays that they were likely to encounter in dealing with the institutes. The streamlined fiscal operation of the newly formed departments has been a powerful incentive for faculty to leave the traditional institutes. Several faculty members with whom I spoke regarded this change as being very beneficial. Not only can the newly formed engineering departments exercise more local control over their financial resources, but, more importantly, the faculty making up the new departments have grouped together because of common interests rather than because of the availability of a chair in one institute or another. Consequently there is a much greater opportunity for professional dialog in the new departments and the intellectual isolation of some faculty members has been removed.

Due to a recent change in Italian law which provides financial incentives to university faculty who attract industrial support and also due to a new program by the Italian National Science Foundation (CNR) to encourage industrial support of university research, such support is beginning to increase. Several aggressive young faculty members with whom I spoke had small contracts with organizations such as AERITALIA, Pinafarina, and the Italian Electric Generating Board.

### Institute of Gas Dynamics

Due to the departure (to the newly formed Department of Mechanical Engineering for Energetics) of several faculty members having interests in experimental methods, much of the fluid mechanics activities of the Institute of Gas Dynamics is of a theoretical nature. In particular, analytical methods are being explored to study mass transfer problems associated with reactive and nonreactive ultrafiltration processes, slip flows in ducts, and the behavior of unsteady jets at low Reynolds numbers. Of somewhat more general interest are numerical implementations of various conformal mapping methods for simply- and multiply-connected domains having application to the development of body-fitted mesh generation techniques.

Recently, Luchini (Luchini, 1987) has developed a numerical solution of the vorticity transport formulation of the Navier-Stokes equations which uses an interesting mesh refinement procedure consisting of a self-adaptive method that dynamically modifies the distribution of mesh points during the calculation. The basis of the procedure is a mesh management algorithm which adds or deletes single points from the mesh in such a manner that each point is always the center of a

symmetrical cross formed with four other points.

Figure 1 shows the result of using Luchini's method for the problem of natural convection in a corner where the flow is generated by the buoyant boundary layer formed on a heated vertical flat plate located along the right hand side of the figure. The addition-deletion process is automatically performed under the control of a routine which determines whether or not the size of each cross is adequate on the basis of the magnitude of the second derivatives of the unknowns. Comparisons of the calculations with analytical solutions and other numerical results for this problem--as well as calculations of free convection in a closed cavity and Heimenz-flow--were carried out; they show that the method is capable of calculating the wall shear stress to within approximately 1 percent. No experimental comparisons were shown. The method has the advantages that the resolution of the calculations is much improved over that which can be obtained with uniform grid procedures. In addition, Luchini claimed that the procedure is easier to program and faster than the competing finite element methods, although no quantitative comparison was provided.

Interesting work on the solution of the Navier-Stokes equations is being done by Professor F. Grasso. Grasso obtained his Ph.D. from Princeton University, New Jersey, and is a frequent visitor there, collaborating with several members, including Professor A. Jameson, of the faculty of Princeton's Department of Mechanical and Aerospace Engineering. Grasso's main interests are in the numerical modeling of two-phase flows and in the transonic and hypersonic computational aerodynamics. The two-phase modeling is being done in conjunction with Professor F. Bracco at Princeton and Dr. V. Magi at the University of Bari. Together they have developed a model for the combustion process in a diesel engine and more recently a rotary engine, which includes a stochastic model of the fuel spray, a generic model of the combustion process, and the solution of the compressible Navier-Stokes equations employing a coupled treatment of the liquid and gas phases.

Grasso's more conventional CFD activities have included the development, in collaboration with Jameson, of a multigrid method for the Navier-Stokes equations which has been applied to both transonic and supersonic and laminar and turbulent, two-dimensional flows (Martinelli, et al., 1986). He has also been involved in the development of a grid embedding procedure which he has applied to

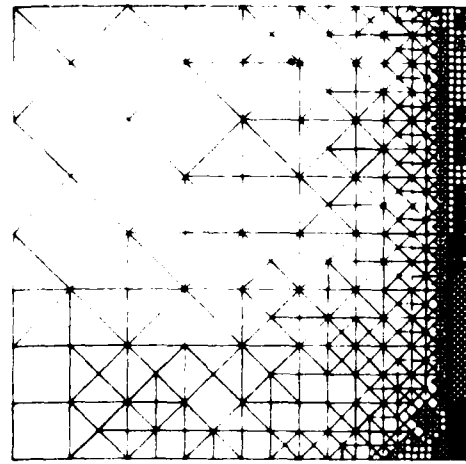


Figure 1. Mesh refinement results for a natural convection problem.

Navier-Stokes calculations in a double-throat nozzle. Rather than divide quadrilateral cells into smaller triangular ones like Luchini, Grasso divides his quadrilaterals into smaller quadrilaterals and uses an interesting implementation of multigrid strategy to couple the solutions in the original and the embedded zones. In zones where the embedding criterion (based on the cumulative distribution function of pressure gradient) is exceeded, finer cells are generated by halving the mesh in both coordinate directions. Time-stepping is performed separately on the solution vector on each grid so that different algorithms can be used in different regions depending on the accuracy required. A conservative technique is used to couple the grids at the interfaces. The results showed some oscillations on the fine grid due to the interface treatment, and, as the Reynolds number was increased (to 6400), the oscillations became more evident. Grasso is carrying out supersonic turbulent boundary layer calculations in support of the European HERMES project and is currently involved in replacing the Baldwin Lomax algebraic turbulence model with the  $k-\epsilon$  model.

Professors C. Meola and G. Carlo-magno have recently left the Institute for Gas Dynamics and joined the Department of Mechanical Engineering for Energetics. Professor Meola's interest is in the mathematical properties of the Navier-Stokes equations, particularly their convergence properties and optimal methods for their solution. In this latter connection he has developed an interesting vector potential/vorticity solution for the problem of the flow produced by a rotating submerged disk located at one end of an open tank. The calculations



have somewhat limited resolution since they were done on an HP 1000 minicomputer. Although these calculations are laminar (and at the moment somewhat provisional) they may eventually be of some value in understanding the surface waves produced by propellers. I plan to stay in contact with this work, and Meola promised to send me his paper once this work is published.

Professor Carlomagno's interests, unlike those of other faculty members I met, are largely experimental. His work shows an amazing amount of diversity. He has developed a schlieren interferometer system for mass diffusion measurements in two-dimensional jets, methods for determining local convective heat transfer coefficients by means of infrared thermography, and, in collaboration with the NASA Langley Research Center, a method for performing low-density, aerothermodynamic studies by a tethered satellite system.

For his mass diffusion studies, Carlomagno used a Wollaston prism interferometer which, although having the advantages of being relatively cheap, insensitive to vibration, and easy to set up, has the disadvantage that it requires an integration process in order to determine the values of the density. To avoid the tedium of carrying out this process, Carlomagno has developed an optoelectronic sensing device using a linear array of 1024 bar-shaped, silicon photodiodes and a computer-controlled stepping motor to analyze the images. (Carlomagno and Rapillo, 1986.)

His interests in determining local heat transfer coefficients are related to the HERMES Project. He hopes to use the thin-film technique in conjunction with infrared scanning (IR) radiometry for making local heat transfer measurements on a flat plate under an impinging jet to simulate the local heating conditions on the HERMES' skin. (Carlomagno and de Luca, 1986.)

Finally, the Tethered Satellite System (TSS) which he and NASA Langley are proposing is intended to collect drag, heat flux, skin temperature, and atmospheric composition measurements by towing a 1.6-meter ball on a 100-km cable beneath the Shuttle. In this way it is proposed to use the atmosphere as a wind tunnel to collect information on gas surface interactions at a wide variety of Knudsen and Reynolds numbers (Carlomagno et al., 1986).

#### Institute of Aerodynamics

Unlike the Institute of Gas Dynamics, the Institute of Aerodynamics, headed by Professor Napolitano, appears to be flourishing. At the present time

Napolitano and many members of his staff are involved in the planning of the new Italian Center for Aerospace Research called CIRA (Centro Italiano di Ricerche Aerospaziali), of which Napolitano is the Scientific Committee Chairman.

This center, for which planning was begun in 1984, will be funded by a combination of money from Italian aerospace industries and federal money from funds earmarked for the industrial development of southern Italy. The center will be a major undertaking, involving the construction of a new large-scale wind tunnel, the development of a supercomputer center for aerodynamic simulations, and an information center with nodes to major aerospace data bases and document acquisition and retrieval facilities.

A large low-speed wind tunnel will be the Center's principal experimental facility. The current design is for a  $4.5 \times 3.5\text{-m}^2$  test section, pressurized (4 to 6 bar), with speeds from 80 to 140 m/s, and a maximum Reynolds number per metre of  $7.3 \times 10^6$ . This will give it characteristics similar to the F1 wind tunnel of the Office National d'Etudes et de Recherches Aéropatiales (ONERA) at its Le Fauga-Mauzac Center. In addition, a  $1 \times 1\text{-m}^2$  cryogenic wind tunnel is planned which will complement the new European transonic wind tunnel (ETW). The headquarters will be located at Kapua, which is approximately 10 miles north of Naples. Projected number of employees at the center is 600. The Italian aerospace industry has already pledged \$250 million of combined federal and industrial funding. The plan is to commission the low-speed wind tunnel in 1992.

Many of Napolitano's former faculty are now involved in the planning of CIRA's computer center, which will be used for aerodynamic simulations and also to perform expert system (ES) analysis of the results. Napolitano envisages that ES analysis will provide a critical evaluation of the simulations by comparing them with experimental data. He made the point that the real bottleneck these days in assessing the validity of either experiment or simulation is that a human being must sit down with the experimental data on one hand and the calculations on the other and try to make a critical evaluation of their respective shortcomings, and it is here that he expects ES to play an important role. To prepare for the eventual implementation of such a system, expertise is being developed at CIRA in the areas of grid generation, parallel and vector processing languages, and--most importantly--expert systems.

The faculty members who have remained with Napolitano at the Institute



are currently working on microgravity problems. To support these activities NASA has organized a Microgravity Applications, Research, and Support Center (MARSC). This \$5-million facility, which is benefitting from the same federal and industrial development funds which are helping to finance CIRA, will be dedicated to examining fluid dynamics problems in microgravity, including rotating flows.

His attitude toward microgravity work, as well as the current activities of his former faculty now at CIRA, is a reflection of his basic research philosophy. His point of view as a scientist and as an institute director is that the only way that you can survive is to be at the forefront of current scientific developments. More often than not, this means you must be willing to change the problems you are working on as scientific and national priorities change. Otherwise, he said, you relegate yourself and your institute to working in an intellectual backwater.

#### Conclusions

A wide variety of fluid mechanics research is being undertaken at the University of Madrid including both the fundamental and applied work. Although the activities are primarily theoretical, the experimental in nature, instrumentation development work is being done in the new Department of Mechanical Engineering for Energetics, which links with the new Italian Center for Aerospace Research (CIRA) to provide a strong incentive for continuing the development of aerodynamic research at the university.

#### References

1. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
2. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
3. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
4. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
5. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
6. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
7. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
8. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
9. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).
10. J. Martinelli, L. A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).

Martinelli, L., A. Jameson and F. Grasso, "A Multigrid Method for the Navier-Stokes Equations," *AIAA-86-0108*, (1986).

J. Martinelli

#### FLUID MECHANICS AND COMBUSTION RESEARCH AT THE POLYTECHNIC UNIVERSITY OF MADRID AND THE UNIVERSITY OF ZARAGOZA

by Eugene F. Brown.

#### Polytechnic University of Madrid

The Polytechnic University of Madrid is located in Ciudad Universitaria, approximately 3 miles northwest of the city center in a beautiful parklike setting. It offers programs in the traditional engineering areas along with computer science, architecture, and forestry. The current enrollment is 35,000.

My visit was to the School of Aeronautical Engineering, in particular, to the Department of Fluid Mechanics, which is headed by Professor Amable Liñan, my host during my visit. The school has an enrollment of 1500 and in addition to fluid mechanics consists of departments of laser physics, propulsion, and hydrodynamics, to name a few. It was founded in the 1950's and is the only school of aeronautical engineering in Spain.

The Department of Fluid Mechanics consists of six professors and a similar number of graduate students pursuing research in the areas of laminar/turbulent transition, combustion, hydrodynamic stability, biological fluid mechanics, digital image processing, and computer graphics. Each year the department graduates approximately 120 students from its nominally 6-year program.

The Department of Fluid Mechanics has excellent connections with the California Institute of Technology (Cal Tech) as a result of Theodore von Kármán's visits to Spain in the late 1940's and von Kármán's subsequent research collaborations in the field of combustion with various faculty members in the Polytechnic University's School of Aeronautics. For more than 30 years there has been a constant stream of students leaving Madrid to obtain their Ph.D.'s in the US, not only at Cal Tech, but at the Carnegie Mellon University, the University of Southern California, the University of California at Berkeley, the Massachusetts Institute of Technology, Yale University, and Stanford University. Many former students have remained in the US to become

through visits at these institutions. Through these individuals and through collaborative research projects involving members of the scientific staff, the Department of Fluid Mechanics has excellent contact with the US fluid mechanics community.

Major sources of departmental research support include the Spanish National Research Foundation (CICYT) and the Spanish Inter-Committee for Scientific and Technical Cooperation. The latter provides substantial US Spanish collaborative support with money provided by the Spanish Government; the presence of US scientists in Spain. There is also a substantial amount of industrial funding to the department, principally from the company Aeronautica, S.A., and the Spanish aerospace group which is involved in the European Combat Fighter Aircraft (EFA), project. As in Italy, industrial support of university research is fairly new, and although there is a strong interest on the part of the sponsor, for example, the company's transonic wing codes, CASA is not yet a dependable source of support. The department's relationship with IBM and, in particular, the IBM Scientific Center in Madrid, is well established. IBM currently supports 31 percent of one faculty member's time. Professor J. Jiménez, whose interests are in digital image processing, computer graphics, and parallel computing. The computational and image processing implications of Professor Jiménez's work to IBM's product line is obvious, which clearly accounts for the success of this arrangement and accounts well for IBM's donation of a substantial amount of image processing equipment to the department.

Professor Llanas's interests are in the field of combustion, to which he has made an important theoretical contribution beginning with his work in the field of aerospace combustion and mixing sponsored by the US Air Force Office of Scientific Research more than 20 years ago. His principal US collaborators are Professor J.A. Williams of Princeton University, Professor P.A. Libby of the University of California, San Diego, and, in France, Professor P. Clavin of the University of Grenoble (Marseille, France), Professor J. H. of the University of Poitiers (France), and Professor N. Peters of the Rheinisch-Westfälischen Technischen Hochschule Aachen (West Germany).

Professor Llanas's current research includes the development of simplified reaction models and the flame properties such as flame speed, extinction; observations and understanding of the

structure of the combustion which occurs at the boundary of diffusion flames; and describing the process of flame propagation in laminar mixing layers. Llanas believes that what is needed in this latter connection, particularly as regards the problem of flame blow-off, is a triple-deck approach in which boundary layer modeling of the outer fuel and oxidizer streams is combined with a local, elliptic Navier-Stokes calculations at the burner tip.

Professor Jiménez's interests are in the area of computational fluid dynamics and digital image processing. He obtained his Ph.D. from Cal Tech in 1973 and returned for a sabbatical year there in 1981-82, during which he began an interesting study on the inviscid stability of the planar Kármán vortex street in collaboration with Professor T. Saffman. In Jiménez (1987a) he showed that the isolated stability characteristics of the Kármán vortex street is an intrinsic property of any two-dimensional (2-D) inviscid array of vortices that has back-to-fore symmetry and is not an artifact of the point vortex model used in Kármán's original stability calculations.

Jiménez has also made an important contribution to the study of transitional (laminar/turbulent) Poiseuille flow with his recent calculations of bursting (Jiménez, 1988b). Although the bursting phenomenon has been known to exist for many years, Jiménez stated that this was the first time it was observed in a computation. Jiménez's calculations make use of a spectral code in which the effects of nonlinear wave propagation are included. He showed that Poiseuille flow undergoes a 2-D bifurcation from the "upper" branch of the basic nonlinear traveling shear wave train, into a limit cycle that later may undergo further evolution into more disordered states. The nature of this cycle is an instability of the vorticity "spots" in the boundary layer, followed by an "ejection" of vorticity into the core flow. Jiménez continued his work in this area at Stanford University this past summer in connection with the NASA-Ames workshop on the numerical simulation of turbulent flows.

Jiménez's interest in turbulent mixing began with his work on numerical modeling of coherent structures while a graduate student at Cal Tech. More recently he has developed a digital image processing technique (Jiménez et al., 1985) which he has applied to obtain three-dimensional images of a mixing layer from laser-induced fluorescence (LIF) motion pictures taken in the early 1980's at Cal Tech. In the motion pictures, consisting of thousands of

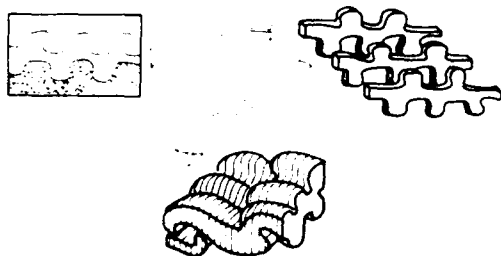


Figure 1. Schematic of a three-dimensional construction of a turbulent mixing layer.

taken at a fixed downstream location as the structures evolve in time, Jiménez constructed a 3-D representation of the mixing layer by converting the third dimension, time, into space by using a fixed convection velocity equal to the average between the two free-stream speeds. Figure 1 is a schematic representation of the construction process. This work was partially funded by the Office of Naval Research.

Jiménez has also recently completed the calculation of Stokes flow in a thermally driven cavity (simulating the geothermal flow of magma beneath the earth's mantle) and the development of numerical methods for the modeling of sprays. This latter work is being done in collaboration with the University of Southern California with funding supplied by the US-Spain Committee for Scientific and Technological Cooperation. Although his modeling of this problem has been more or less conventional up to this point, he hopes to develop a two-phase lattice gas simulation for this problem.

In connection with his CFD-related activities, Jiménez's relationship with IBM has proven to be particularly valuable since it has given him access to the company's extensive networking services and thus provided him not only with instantaneous online contact with his collaborators in the US, but also virtually unlimited access to the IBM 3090 at the Spanish Atomic Energy Commission.

#### University of Zaragoza

Fluid mechanics activities at the University of Zaragoza are found in the Department of Fluid Mechanics, which is a part of the School of Industrial Engineering. My host during my visit was Professor César Dopazo, who is the head of the department. Professor Dopazo has a strong interest in turbulent combustion and is internationally recognized for his work on Monte Carlo simulations of turbulent reacting flows.

Although the University of Zaragoza is the sixth largest University in Spain, the School of Industrial Engineering (embracing the disciplines of mechanical and electrical engineering) is the third largest (after Madrid and Barcelona). Although Dopazo's department is small (two professors and three research associates), it is well funded, well equipped, and housed in spacious new quarters approximately 5 kilometers from the downtown campus. Dopazo's new combustion laboratory is equipped with a Dantec two-component laser Doppler anemometry (LDA) system including a computer-controlled three-dimensional traversing mechanism, a PDP 11/23 data acquisition system, and a Malvern (diffraction sensitive) particle sizing instrument. To support its computing activities, the department has access to the university's VAX 11/780 and IBM 340 and soon will have access to a Cray 1S recently purchased from Office National d'Etudes et de Recherches Aéronautiques (ONERA) by the Spanish Ministry of Science and Education and CASA.

Dopazo's problem is not money, it is people. He has been unable to obtain governmental approval to increase the size of his department. In fact, he said, with twice the number of people, he still could not do all of the work which he would be able to obtain funding for. His biggest need at the moment is to find someone to direct the construction of his new combustion laboratory. He is eager to find a well-trained specialist or post-doctoral student from the US to complete and commission this new facility.

Although the attitude of the Spanish government toward university research has changed from that of benign neglect to active support through CICYT, far more money can be obtained from industrial contracts Dopazo said. The majority of the department's work is now involved in such a contract with a Spanish electric-power utility. The research involves carrying out experiments on and developing computational codes for heavy-oil-fueled industrial burners. For this project, Dopazo intends to use his LDV equipment in conjunction with the Malvern instrument to obtain simultaneous velocity and particle size measurements in high-pressure (60 bar) sprays. For this purpose he has made a 1/3-scale prototype burner on which he has already made preliminary measurements. A novel feature of these experiments is the use of a radial deconvolution technique applied to measurements made at nine different points in the spray to obtain the radial distribution of droplet size.

The computational aspects of this project involving models for drop formation, vaporization, combustion, and the

effect of swirl are being carried out in a 4-year program in collaboration with Professor B. Spalding and Professor W.P. Jones of Imperial College (UK). This work will be carried out by a Spanish Ph.D. student who is now at Imperial College. Although this student will be using Spalding's two-fluid model, Dopazo has his own ideas about the proper modeling of sprays. He has developed what he believes to be the most rigorously defensible governing equations obtained to date, using what he calls an "indicator" approach for the continuous phase and a Boltzmann-like approach for the dispersed phase. To include the effects of turbulence he uses the k- $\epsilon$  model for the continuous phase and has found a way of relating the kinetic energy of the dispersed phase to the kinetic energy of the continuous phase. In this way, only 3 or 4 terms in addition to those required to model a continuous phase flow are required. Already the technique has been applied to the flow in an axisymmetric jet in which it was found that the mean velocity, turbulence stresses, turbulence kinetic energy, and to a lesser extent the center-line velocity could be accurately predicted. For modeling combustion effects Dopazo proposes to use a probability density function (pdf) approach in conjunction with a Monte Carlo method.

#### Conclusions

Because of the lack of an established tradition of fluid mechanics research in Spain, there exist only a few centers such as those in Madrid and Zaragoza which have well-developed research programs. To some extent this has been fostered by the attitude of the national government which, as reported to me, has long regarded research as an unwelcome adjunct to teaching. There are signs that this is changing with the establishment of a national agency for funding university research (CICYT) which has already introduced special-focus programs to encourage research in fields of current technological importance such as semiconductor physics. Such a program in the area of fluid mechanics has recently been proposed, and a cataloging of current fluid mechanics research activities and resources is just now nearing completion.

With the prospects of increased national support and with the increased interest of Spanish industry in university research, it is likely that the next few years will see a sharp increase in the number of Spanish universities developing high-quality research programs in the field of fluid mechanics.

#### References

- Jiménez, J., "On the Linear Stability of the Inviscid Kármán Vortex Street," *Journal of Fluid Mechanics* (1987a).  
 Jiménez, J., "Bifurcations and Bursting in Two-Dimensional Poiseuille Flow," (Manuscript submitted to *The Physics of Fluids*, June 1987b).  
 Jiménez, J., M. Cogollos, and L.P. Bernal, "A Perspective View of the Plane Mixing Layer," *Journal of Fluid Mechanics*, 152 (1985), 125-143.

8/6/87

## Ocean Sciences

### COST-43: SEMINAR ON OPERATIONAL OCEAN STATION NETWORKS

by Jerome Williams. Professor Williams is the Liaison Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the US Naval Academy, where he is Associate Chairman of the Oceanography Department.

Created in 1970 from Working Group 43 of the European Cooperation in the Field of Scientific and Technical Research organization, COST-43 has been coordinating and encouraging the deployment and use of both national and multinational data buoys for 17 years. These include both drifting and moored buoys. The fifth COST-43 technical seminar was held in June 1987 at Brest, France, where the host organization, Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), has its largest laboratory facility (see page 61). The papers presented at this meeting have been issued in a seminar proceedings and are available from the COST-43 Technical Secretariat, Christian Michelsen Institute, Fantoftvegen 38, N-5036 Fantoft-Bergen, Norway.

#### COST-43 Programs

A very appropriate opening to the conference was offered by D.N. Axlerod, UK Meteorological Office, who described the development and activities of COST-43 from the early days to the present. Following its formation in 1970, various study committees were organized, but it

wasn't until 1975 when the Martinis Report appeared that anything significant happened. This was the result of much work accompanied by a great deal of insight, and it was to point the way for activities of the next decade. The report looked at buoy requirements and technology, proposed design standards (including those for data transmission), and pleaded for the pooling of European efforts and resources. Following the recommendations of the Martinis Report, the European Network of Ocean Stations (ENOS) was established in December 1977. This established a permanent working group on systems and set up pilot networks in selected test areas, including: the Azores, Bay of Biscay, The Faeroes, the North-Sea Baltic Region, and the Mediterranean. By January 1983, Belgium, France, the Netherlands, Spain, Denmark, Iceland, Norway, Sweden, Finland, Ireland, Portugal, and the UK were all members in good standing of COST-43, with Italy and West Germany joining as observers. Although COST-43 is scheduled to cease operations in 1988, the general feeling of the participants at this meeting was that the activities would continue, with the major emphasis being a shift in emphasis from international to interlaboratory cooperation.

The system of Operational (drifting) buoys in the Atlantic (SOBA) was created in 1984, with France, Iceland, Ireland, the Netherlands, Norway, and the UK as active participants. This was followed in 1986 with the South Atlantic Cooperative Network of Drifting Ocean Stations (SCOS), consisting of inputs from France, the Netherlands, Portugal, Spain, and the UK. As a result of this series of cooperative efforts, over 60 Ocean Drifting Observation Systems (ODAS) and other stations were deployed, four major technical seminars were held, more than 300 technical documents were published, and there was much exchange of information and data, along with a successful attempt to intercalibrate all deployed sensors. P. Axford expressed the view that, if not all, of the participants that COST-43 was an excellent example of an international venture that worked.

After Axford's presentation, J. Rolin of France's Centre de Meteorologie Marine (CMM), described a joint venture between the British Meteorological Office and the CMM. The two groups chose to moor a Bathythermograph 100 meters of water at a site 100 km west of the southern tip of Ireland, measuring atmospheric pressure, sea temperature, wind speed and direction, and sea-surface temperature. Data were transmitted using the ARGOS system.

A total of eight automatic marine weather stations used by Finland mostly at island locations in the Baltic, Gulf of Bothnia, and Gulf of Finland were next described by H. Gronvall, Finnish Institute of Marine Research, Helsinki. Wind speed and direction; atmospheric pressure, temperature, and humidity; and sea-surface temperature and conductivity were measured at these stations. The stations have a good reliability record, with an average "up" time of 85 percent. Interestingly enough, comparison of wind data taken at these over-water locations show wind speeds twice as great as those measured over land.

The technical and operational experiences of the SOBA program were reviewed by T. Kvinge, Christian Michelsen Institute, Bergen, Norway, who was personally involved with evaluating various specific drifting buoy types over a period of 3 years. Instrumentation varied from buoy to buoy with a minimum of air pressure and SST being measured. Since the ARGOS system determines buoy location during telemetry, allowing for a calculation of surface drift, the data were collected using this system. A total of 17 buoys have been deployed in this program, 13 of which have completed their active lives. Of the 13 that are no longer in service, lifetimes varied from 0 to 420 days, with an average life span of 172 days. Six of the buoys lasted longer than 200 days, while three lasted less than 10 days.

Along a similar vein, the SCOS program was discussed by P. Blouch (CMM). Between November 1986 and March 1987 two buoys were deployed. Unfortunately, both died prematurely with the first lasting 3 months and the second only 1 month, but the SCOS group plans to deploy others in this series in the near future. These buoys have the potential for producing some rather unique and valuable data, since they include a thermistor chain allowing temperature profiles to be obtained to depths of 100 meters.

In addition to lifespan problems, there are also problems with some of the buoy sensors used. Tests made on sensor performance before deployment of SOBA buoys showed a spread of temperature readings greater than that prescribed by specifications, according to A.W. Brewer of the UK Meteorological Office, Bracknell. The pressure sensors also seemed to be below par since the pumping effect of winds greater than 40 knots produced atmospheric pressure readings with errors greater than 1 hPa.

#### National and International Programs

Data-gathering efforts of the World Meteorological Organization (WMO) and the

Intergovernmental Oceanographic Commission (IOC) were briefly described by P. Dexter of WMO, Geneva, Switzerland. He indicated that over 7500 ships participated in the WMO network, but there are still tremendous geographic areas from which there is no data input. The same lack of data in essentially the same areas is exhibited by XBT reports supplied by the Integrated Global Ocean Services System (IGOSS), a ship-of-opportunity data-gathering net coordinated by IOC. It would seem that these "holiday" areas are ideal locations for drifting buoys, while at the same time, the well-trafficked regions present an ideal opportunity for buoy calibration.

Another international data-gathering net still in the planning stage is the Operational World Weather Watch System (OWSE). J.M. Nicholls of the UK Meteorological Office, Bracknell, discussed a design evaluation scheme that has been proposed for the North Atlantic portion of the system (OWSE-NA). The objective is to design an observing system for real-time data which is to be put in place by the 1990's. One of the problems to be addressed is that the soundings taken aboard ship between midnight and 0600 are often not transmitted due to radio officers not being on duty at that time. Various systems in use during 1987-88 will be evaluated including ships of opportunity, buoys, moored platforms, aircraft, satellites, and land (island and coastal) stations. At the present time Canada, Finland, France, West Germany, Iceland, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the USSR, UK, and US are all involved in the project.

There are also other information systems used by various countries to acquire continuous oceanic data for their specific purposes. A Canadian effort employing automated weather stations aboard Japanese automobile carriers as ships of opportunity was described by G.E. Wells, Atmospheric Environment Service, Vancouver, Canada. This was followed by a discussion of a French effort to measure the upper Azores current using surface drifting buoys, presented by C. Maillard (IFREMER), and a portrayal of a permanent American network of between 10 and 20 Arctic buoys by P. Colony from the University of Washington (Seattle), which maintains the system.

The methodology and techniques of data quality control used by the US National Data Buoy Center (NDBC) were described in some detail by D.B. Gilhousen of NDBC, Washington, D.C. He indicated that this program has four specific objectives: edit data, indicate need for service visit to accessible facilities,

help diagnose component failures, and provide insight into sensor design deficiencies. A simple algorithm relates the measured value to statistical parameters associated with historical data, and the decision to be made as to whether the value should be retained or not. The record of data retention for a particular sensor is also monitored for information pertinent to service requirements and component failures. By using this methodology, Gilhousen is confident that it will be possible to provide quality control in real time in the very near future.

Real-time current measurements are required in Swedish waters for accurate oil dispersion forecasts and navigational purposes, since flows as great as 1 m/s are not uncommon. A program to design and develop a suitable measuring system was reviewed by I. Mattisson of the Swedish Meteorological and Hydrological Institute, Stockholm. Early on, the decision was made to go with an automatic station, since other systems are very expensive to maintain and use. The institute is now in the process of testing a bottom-mounted acoustic Doppler current profiler, coupled with an inverted echo sounder for surface wave measurements. With the profilers operating at depths greater than 30 m the experimenters hope to obtain current measurements at depth intervals less than 5 m with an accuracy of  $\pm 5$  cm/s, and they are planning on maintenance intervals of greater than a year.

#### Evaluation and New Developments

The results of an evaluation of the performance of two data buoys over a period of 4 years was presented by D.F. Forsdyke, Thorn EMI Electronics, London, UK. These buoys were designed to measure air temperature, SST, water temperature at a depth of 3 m, surface waves, wind speed and direction, air pressure, and surface current. With the single exception of the current sensors, which have been inoperative for the entire period, the units, moored in 600 feet of water, have performed well for the past 4 years.

Representing the Deacon Oceanographic Laboratory, Wormley, UK (DOL), Paul Collar described his efforts at measuring currents in the surf zone. Under the sponsorship of the Scientific Committee on Oceanic Research (SCOR), an acoustic magnetic sensor current meter was mounted on the underside of a float, resulting in a system rugged enough to survive 20-meter waves. Examination of the data shows a high correlation with wind after tidal currents have been subtracted out. The data also exhibited a good agreement with HF radar data.

The Danish Institute of Marine Research has developed a new buoy to meet the special requirements of high-latitude environments. It was described by O. Kornerup of the Institute. Both atmospheric and oceanic sensors are included in the instrumentation suite mounted aboard the instrumentation buoy. Atmospheric parameters measured are wind speed and direction at 4.5 m above the sea surface, humidity, temperature, pressure, and salinity. In the water, on the other hand, temperature, both at the surface and at depth (with a thermistor chain), currents, and surface waves will be measured. In addition to these instruments, the buoy carries a small computer on board, allowing data acquisition and storage, re-programming, onboard data processing, systems fault analysis, and data telemetry schedules to be generated and changed. The unit is now being tested, and tests are going well enough to expect deployment in the very near future.

Another instrumented buoy with some "intelligence," this one designed to exclusively measure wave height and period, was discussed in some detail by J. L. F. (JFREMER). Called SPEAR-F, this is a wave-rider type that requires no external support and has no range limitations. It employs a data telemetry system designed to utilize the ARGOS system. Installed aboard SPEAR-F are two microchips to give the corrected wave height using fast Fourier transform techniques. Thirty frequency bands with periods ranging from 2.6 s to 23.1 s are available, allowing easy checkout before deployment. The buoy has not been in use long enough to reach a final conclusion about its reliability, but initial tests, at least, the data received up to this point are very encouraging.

On a somewhat different vein, R. J. (JFREMER) addressed the problems of using a buoy network to measure the ERS-1 scatterometer and altimeter sensors. In particular, he discussed the development of an optimal sensor placement, taking into account the varying characteristics of the ocean and satellite sensors.

It was interesting, and somewhat surprising, to me to attend a conference in an area of technology I thought was 20 years ago, but have found it very much with recently. It was also interesting that there is some evidence that the technology, such as onboard computers, being applied to the ocean. At the same time it was also interesting to see the same problems of reliability and data interpreta-

tion the buoy community has been struggling with for the past 20 years are still with us. The air/ocean interface where buoys live is probably one of the most hostile environments on earth, so it is not surprising that problems still remain. What is surprising is that there are still so many problems. One of the most upbeat impressions I did come away with was the excellent record of COST-43 with respect to international cooperation. Apparently if everyone gains, everyone cooperates. It appears to me that since everyone has much to gain this spirit will continue at the institutional level, even though COST-43 will officially disappear next year.

7/19/87

#### AIR-SEA INTERACTION MEETING OF THE UK'S ROYAL METEOROLOGICAL SOCIETY

by Jerome Williams.

For 2 days in July, 1987, Southampton University played host to the Royal Meteorological Society summer meeting, which focused on the general area of air/sea interaction. Although this was essentially a regional meeting of the society, over 50 British investigators participated in the 2-day session, which addressed many different aspects of the air/sea (-ice) interface from what seemed to be primarily an oceanographic point of view.

#### Bubble Clouds

The program was started by S.A. Thorpe from Southampton University, who discussed the clouds of bubbles produced by waves breaking due to group velocity-produced instability. Using 248 kHz side-scan sonar placed on the bottom, he was able to observe these bubbles moving at the current speed before they dissipated after about 1-5 minutes. The sonograms obtained showed marked changes in speed of motion at frontal zones, and they also clearly showed regions of Langmuir circulation (wind rows). During periods of precipitation, acoustic backscattering is increased, bubble clouds are formed continuously, and they last much longer. Bands of bubble clouds also appear to be entrained by internal waves, so that height, speed, and wavelength may be inferred from the sonograms. In addition, internal waves seem to cause breaking of surface capillary-gravity waves under certain conditions, producing surface

bubble clouds. This may have a significant effect on the internal waves themselves as wave energy is converted into bubbles. Bubble distribution appears to be related to various forms of turbulence, and there also seems to be a correlation between bubble population and small ( $10^{-3}$ °C) temperature anomalies. From these experiences, Thorpe is convinced that bubble clouds can be used as a naturally occurring tracer in the study of many hydrodynamic phenomena.

#### Fluxes

An experiment to measure heat and momentum fluxes across the air-sea interface on a monthly mean basis was described by P.K. Taylor of the Deacon Oceanographic Laboratory (DOL). Working within a square 200 km on a side to resolve the spatial effects of synoptic features while averaging most mesoscale features, Taylor used data from Voluntary Observing Ships (VOS), research vessels, and buoys. He believes that these fluxes are an important part of the climate system and therefore reliable values are required to both drive and verify coupled ocean-atmosphere models. Monthly mean data were used to allow resolution of the seasonal cycle. One of the byproducts of this study was an analysis of the VOS data source, which indicated that VOS were consistent, but biased, especially for wind data where the bias is on the high side.

#### Fronts and Gradients

A portion of another experiment, the Frontal Air Sea Interaction Experiment (FASINEX), was described by R. Pollard (DOL). He is looking at frontal density and velocity fields in the hydrosphere. Using CTD, oxygen, and acoustic Doppler current meter data in an Ekman convergence region near Bermuda, Pollard has succeeded in producing a picture showing many discrete fronts within this frontal area. These data are in agreement with previously derived dynamic plots, even though vertical velocities of 50 m/day are indicated. However, he is able to verify these values from vertical movement measurements taken with neutral density floats.

The question of the cause of ocean stratification was addressed by John Woods of the National Environmental Research Council (NERC). He believes that horizontal potential vorticity gradients control mesoscale dynamics, and that stratification results from the spring rise of the mixed layer. In addition, the strength of the stratification appears to be related to the correlation between the mixed layer depth and its average density, with this correlation determined by

buoyancy flux and gyre circulation, and not by Ekman pumping.

#### Remote Sensing

An excellent review of attributes and characteristics of various microwave sensors used to sample the sea surface was presented by T.H. Guymer (DOL). He limited his discussion to the altimeter, the scatterometer, and synthetic aperture radar (SAR), since these will be the major elements of the ERS-1 instrumentation suite. The altimeter seems to work quite well when used for the measurement of significant wave height because the returned pulse shape varies in a predictable manner with wave height. Empirical algorithms have been developed that have good correlations with in situ data for significant wave heights up to 8 m. Although the operation of the scatterometer is not too well understood when used for wind speed determination, empirical relations seem to give accuracies better than  $\pm 2$  m/s. Since the scatterometer apparently measures something akin to surface roughness, or capillaries on the sea surface, the time constant of the system is quite small as ripples respond quickly to the local wind. The SAR signal is also related to small-scale surface roughness, and thus can be thought of as a very-high-resolution scatterometer. Unfortunately, the SAR signal is also related to wind speed, atmospheric stability, wave-current interaction, rain, viscosity (and thus sea-surface temperature), and platform characteristics. Guymer wonders whether SAR raises more problems than it solves. More knowledge is needed regarding spatial structure of the sea surface at very short wavelengths and the nature of biasing of sea-level estimates.

An entirely different type of remote sensing activity was discussed by C. L. Hepplewhite of Oxford University. He described a cooperative program between Oxford and the British Antarctic Survey where a radiometer was suspended from the bow of a research vessel as it transited from the UK to Antarctica, and the resulting data were compared with satellite IR measurements. Called Remote Observation of the Sea Surface and Atmosphere (ROSSA), its objectives were to verify atmospheric window transmission models, study the skin-temperature bulk-temperature relationship, and develop retrieval techniques for satellite ocean circulation. Preliminary findings indicate that the skin temperature is a function of the bulk temperature, and the skin effect is established within 4 minutes after local mixing.

#### Models

A number of different models were described at the meeting.



first was a prediction model, presented by J.P. Barker of the Meteorological Office (MO), and was designed to use historical sea-surface temperature (SST) data to allow precipitation forecasts to be made. Since marine data collection was started in the middle of the 19th century, the MO has acquired a large body of data, including over 60 million ship observations. These data were used sequentially in the forecast model, and a correlation between southern hemisphere SST and precipitation over the northern part of Africa was noted. It appears that southern hemisphere oceanic warming is associated with North African droughts.

A different type of model involving the El Niño Southern Oscillation (ENSO) and its relationship to equatorial long waves was introduced by G.R. Bigg (University of East Anglia). Bigg considered the equatorial zone to act as a wave guide, trapping disturbances near the equator. Equatorial Kelvin waves would be produced, with the wind stress acting as the forcing function in this case. A model incorporating these concepts should fit ENSO events of a year or so in duration, and the event of 1982-83, including the XBT data, is indeed described quite well. The model does not seem to be applicable in cases where the ENSO event lasts for an extended period of time, however.

Some of the problems inherent in the development of coupled ocean-atmosphere climatological models were discussed by J.L. Parman (MO), as he chronicled the evolution of such a model with the appropriate air-sea interaction terms. Since the ocean is heated from above and the atmosphere is heated from below, the convection is in the opposite direction, allowing the introduction of many hard-to-avoid systematic errors. Nevertheless, Parman is attempting to couple an ocean and an atmospheric model for a 5-day cycle. The atmospheric model has 11 vertical levels, uses gravity wave drag, and includes terms for solar radiation, cloud formation processes, and precipitation. The ocean model has 17 vertical levels and considers solar radiation, convection, moisture exchange, winds, diffusion, and diffusion. The model is currently in the process of being refined and tested.

The complexity of typical tropical ocean-atmosphere dynamical models was discussed by V. K. Davey of the Hooke Institute, who indicated that one such model requires several hours of computer time to run for a 10-day period. He is working on a new model which, although it includes some essential effects, will not be able to compete with present models, but will

give insight as to the sensitivity of the various parameters under consideration.

### Ice

As pointed out by B.G. Gardiner of the British Antarctic Survey (BAS), ice presents a unique problem in studies involving the air/sea interface, because of difficulties in description, modeling, and sensing. It is difficult to distinguish between snow cover over sea ice and over land, and--even worse--the albedo of open water sea ice is about 0.25, while for fast ice it is about 0.5. Consequently, a great deal of field work is needed to quantify a number of critical ice-associated parameters. Some of the ongoing field work generated in answer to these needs was described by D.W.S. Limbert (BAS), M.A. Rowe of the Hooke Institute, and V. Squire of the Scott Polar Research Institute.

Limbert related some of the details of an experiment performed in the Weddell Sea to determine the relation between meteorological factors and the drift of pack ice. By monitoring a buoy implanted in the moving ice pack, BAS hoped to improve synoptic analysis techniques, increase knowledge of ice movements forced by weather systems, acquire heat flux information, and learn more about water mass transport into and out of the Weddell Sea. Such a buoy was placed in the ice pack and sent data through the ARGOS system for 478 days. The movement of the buoy appeared to follow the 1000-m bathymetric contour, while it exhibited wind-driven anomalies superimposed on the basic residual current. These changes in movement were also substantiated by winds inferred from available weather charts. The average speed of the buoy was about 10 km/day, but net drifts seemed to be about 4 km/day, indicating a rate of ice movement out of the Weddell Sea of 1,500,000 km<sup>2</sup>/yr. This, plus any melted ice, must be replaced by new ice each year, of course, if equilibrium is to be maintained.

The Winter Weddell Sea Project (WWSP) also involved the use of drifting buoys, but in this case, the objective was to determine the relative importance of tidal forces on the observed motion. Rowe recounted some of the results of these measurements. Tidal currents obtained by other methods indicate typical speeds of about 0.5 cm/s, but movements inferred from buoy data indicate velocities associated with motions having tidal periods to be an order of magnitude greater. At this point it is not clear what these motions are associated with, since the 0.5 cm/s values were measured in deep water, while the buoy-associated values are from shallow water areas.

The work of Squire was quite different, since his interest in ice had to do with the effect of the ice edge on wave trains coming from the open sea. He reviewed an experiment carried on in the Weddel Sea where the wave spectrum was measured on both sides of the ice edge (actually the marginal ice zone, a region of floes of various sizes and shapes). As waves move into an ice field, the ice edge is continually being broken up into small floes, wave amplitudes decrease and the shorter waves are filtered out, disappearing from the spectrum. This is apparently due to hydrodynamic effects, floe collisions, scattering effects, and the inelastic nature of ice as it bends. It is not clear at this point which of these effects, if any, is dominant.

#### Summary

This meeting of the Royal Meteorological Society addressing the air/sea interaction problem was a little surprising in that the topics discussed appeared to treat the "sea" part of air/sea almost to the complete exclusion of the "air" part. However, it did point up the fact that at least British oceanographers and meteorologists are becoming more and more aware of the inseparable coupling that exists between oceanic and atmospheric processes. I am hearing with increasing frequency statements that reflect the attitude that processes in one fluid cannot be completely understood without considering those in the other. Having said that, I was somewhat disappointed at the relatively small number of presentations that directly treated air/sea interaction problems at a meeting called specifically to address this subject area. I would suppose that this reflects the fact that there is not too much UK activity in the air/sea interface arena at this time. It is possible that one of the objectives of the meeting organizers was to spark interest in this very important research discipline. One would hope so, since the major problem area in coupled models appears to be a poor understanding of the processes governing the exchange of mass and energy across the air/sea interface.

## Physics

### A SMALL FRENCH MEETING ON OPTICAL COMMUNICATIONS

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1988.

"Telemat 87--Horizons de l'Optique," held at the National Graduate School of Physics, University of Marseille (Saint-Jérôme Campus) from 1 through 4 June, was a new event, combining three previously independent meetings: Telemat, Horizons of Optics, and sessions by a task group of the French Optical Society. Telemat, a biennial event since 1981 is staged by the National Graduate School of Physics (Marseille), and dedicated to contributions of physics to communication technologies. Horizons of Optics, which supplied a good contingent of speakers, is a regularly convened small meeting within the French Optical Society, concentrating on recent progress in optics and its industrial applications. Finally, a regularly meeting task group of the French Optical Society arranged for sessions related to problems of optical computing and the use of optics in computers. The unification of these three elements proved fruitful and the conference was a forum representing optics in the service of information technology and communications.

There were nearly 150 registrants--almost all of them French. The talks were given in French (no simultaneous or ex post facto translations were supplied). I have a book that contains most of the abstracts (it is in French) and may be able to send copies to colleagues who have specific requests. The entire texts of the talks will appear in a special issue (probably in early 1988) of the *Annales des Telecommunications*.

The National Graduate School of Physics (Marseille University), the French Optical Society, and the Society of Electrical and Electronic Engineers were the organizers of the meetings (assisted by contributions from a number of national organizations) and any enquiries should be sent to Professor P. Bousquet, Director, ENSPM, Domaine Universitaire de Saint-Jérôme, F-13397 Marseille Cedex 13. Perhaps I should mention that the honorary president of the conference was Professor H. Curien, the former Minister of

Research and Technology, who actually gave the address on new optoelectronic materials during the ceremonial session of the conference.

The program was grouped into the following four areas:

1. Laser vision and related sensors
  2. Imaging systems and devices
  3. Optical telecommunication (integrated filters, component technology, multiplexing, unusual applications)
  4. Optoelectronic materials and components (including micro-optoelectronics)
5. The role of optics in computer technology.

However, in the Gallic tradition, the proceedings were only approximative. Moreover, various sessions had greatly different audiences--but rarely more than one-quarter of the total number of participants, despite the fact that no parallel sessions were held and no poster presentations disrupted the learned attendance. Thus, I think, the unification of the audiences was less successful than the unification of topics. Possible exceptions were the two, rather informal (and, unfortunately, undocumented) round-table sessions: one on discussing II-IV versus III-V materials for optoelectronics, and one on optical functions in computers.

In the rest of this article, I will select a few papers given in areas 3, 4, and 5.

#### Optical Telecommunication

The session opened with an invited address by A. Vallette (LETI, Grenoble), who reviewed recent progress in integrated optics on silicon substrates. He recalled that, until recently, the structures for light waveguides on silicon substrate were based on multilayered systems of the type  $\text{SiO}_2/\text{Si}_3\text{N}_4/\text{SiO}_2$ . Here, a very large difference in refractive index existed between the  $\text{Si}_3\text{N}_4$  and the adjacent  $\text{SiO}_2$ . LETI developed a line of technology based on this technology, leading to the fabrication of optical circuits with waveguides of different fabrication techniques. However, these devices were limited to coupling to monomode fibers. Therefore, about 3 years ago, LETI started a new line of technology based on multilayers of  $\text{SiO}_2/\text{Si}_3\text{N}_4/\text{SiO}_2$ . These are waveguides with the characteristics of multimode fibers, allowing for large coupling to multimode fibers. The talk described in detail the fabrication of these structures, the wave propagation, the doping of the waveguides, and the first actual applications in optical telecommuni-

cations. Both performance characteristics and cost-efficiency of practical devices appear most promising.

In contrast to the preceding speaker, S. Tedjini, on behalf of IEMO (Grenoble) did not describe painstaking research on devices but rather expanded a somewhat radical idea. He suggested that, instead of transmitting millimeter waves through standard waveguides, it may be profitable to construct a system in which mm-waves are transmitted via a modulated optical wave. The low fiber-attenuation, the very large bandwidth, and the cheapness of fibers, he prophesied, may one day overturn the accustomed mm-wave techniques of today. Tedjini asserted that currently available diode lasers could be used for carrier wave sources, and recent photodetectors with 60-GHz bandwidth may be also appropriate for the purpose of reception. The really difficult part would be the modulator. He suggested that traveling wave electro-optical modulators may be the key to solving the problem of an extremely large bandwidth.

Related, but more down to earth was the talk by Ph. Richin (Thomson-CSF, Orsay) who analyzed optical transmission systems for the multi-gigahertz data flow domain. Transfer characteristics, signal-to-noise ratio, and linearity (as a function of intermodulation) were discussed as domains of concern. One conclusion of the study was that external and direct modulation are both promising and complementary methodologies, but each is valid only in its own domain.

One more talk in the area of optical communication caught my interest. A.S. Galerneau (University of Marseille and the CNRS Laboratory for Surface Optics and Thin Films), reporting on work done in cooperation with Centre National d'Etudes des Télécommunications (CNET, Lannion), discussed the application of interference filters for optical multiplexing. Although the fabrication and experimental evaluation of actual filters was part of the effort, much of the talk focused on an intelligent analysis of the behavior of multichannel optical filters--emphasizing the points that are particularly pertinent to using them for multiplexing.

#### Optoelectronics

The keynote address in this area was delivered by J. Rotureau (University of Nice). His carefully constructed paper was entitled "Fiber Optics in the Nonlinear Regime." He started by reminding the audience of the obvious fact that nonlinear effects in fiber propagation are based on the same physical processes as nonlinear effects in bulk materials.

primarily the variability of the third-order dielectric susceptibility  $\chi^{(3)}$ . In particular, in a monomode fiber this will lead to highly elevated light intensities; the very small attenuation causes also a very long interaction length, leading to spectacular behavior. However, even more important are the nonlinear effects in fibers that are not simply extrapolations of bulk effects. It is important to realize that on one hand, a fiber is an optical waveguide, so that adjustable new degrees of freedom are introduced into the analysis. On the other hand, the different orders of the magnitude of certain parameters are sometimes so large (for fibers as opposed to bulk) that qualitatively new phenomena can be observed. Some of the specifics analyzed by Botineu were purely electronic anharmonicities, self-induced birefringence, three- and four-wave mixing, Raman and Brillouin scattering, and optical solitons.

G.R. Boyer (Ecole Polytechnique, Palaiseau) chose an important topic for his presentation. He talked about the compression of light pulses by utilizing phase automodulation in a monomode waveguide. He reported on experiments in which (from 60-fs-long light pulses produced by a ring laser arrangement) light pulses as short as 13 fs were obtained, with a repetition rate of 10 Hz. As in similar work done elsewhere, the basis of the pulse-compression was the nonlinear optical Kerr effect in a monomode fiber (causing phase-automodulation). The various frequencies thus created were then readjusted in their phase by a dispersive transmission line, which introduced among them a retardation proportional to the frequency deviation from the pulse's central frequency. This process results in a compression which approximately equals the frequency broadening factor. The experimenters used a 30-mm length of polarization-maintaining monomode fiber.

The last talk I wish to report in the context of optoelectronics, was very much materials-science oriented. G. Lecoy (Université des Sciences et Techniques du Languedoc, Montpellier) discussed properties of II-VI, as well as III-V materials, relevant for specific photodetectors. In particular, he considered the wavelength domain 2-4  $\mu\text{m}$ . He recalled a list of parameters that properly characterize photodetectors, and focused on devices which work in the avalanche-regime. Main emphasis was put on the characterization of intrinsic noise. Lecoy showed that the essential characteristic is the "coefficient of excess noise," which is the ratio  $k=\beta/\alpha$  where  $\beta$  and  $\alpha$  stand for the ionization coefficients of holes and electrons,

respectively. In order to study the behavior of this coefficient,  $k$ , the speaker analysed carefully the bandstructure of III-V and of II-VI materials, and displayed an interaction between the following four bands: the conduction band, the "split-off band" (caused by spin-orbit coupling), the heavy holes' band, and the light holes' band. He then showed that the major problem of building useful homojunction devices is to find materials for which either  $k$  or  $k^{-1}$  becomes very large. He noted that "staircase-type" structures allow a large artificial increase in the value of  $k$ .

#### Work Toward Optical Computing

Two invited reviewers opened the sessions on the (possible) role of optical devices in computers. The first, given by D. Comte (the French Aerospace Institute [ONERA], Toulouse), had the challenging title, "From Optoelectronics to Opto-informatics." The second introductory survey was given by A. Lohmann (University of Erlangen, West Germany)--incidentally, the only non-French speaker. His enthusiastic (yet decently restrained) review carried a title as exciting as Comte's: "The Digital Computer: Problems and Chances."

The down-to-earth work started with the talk of A. Niepceon, who represented a group of researchers at the University of Paris-Sud, Orsay. Niepceon discussed painstaking experiments aimed at the optimization of a sapphire-based silicon waveguide for use as an optical bistable device. The Paris group researched the optimization of an all-optical device which should have a rapid switching time and permit the detailed observation of bistability cycles. The basic structure used in the experiments was a nonlinear silicon waveguide epitaxially built on a sapphire substrate, in which one of the guided modes could be excited. The coupling between the light beam and the waveguide was realized by means of a system of holographically engraved diffraction units arranged in sequence. The earlier devices used a silver layer deposited on the silicon. However, a series of studies led the researchers to omit the silver layer, despite the fact that it enhanced the nonlinearity and assisted coupling.

Despite its proximity with ("Optical Switching and Reconfigurable Optical Interconnections"), the talk of G. Roosen (University of Paris-Sud, Orsay) was, to me at least, somewhat disappointing. Roosen presented "critical" the optical analysis of the problem area (the study was done in cooperation with the CNET, Lannion Laboratoire). Both the science and technology aspects of materials science were included in the study. The

major conclusion was that holographic techniques may satisfy an entire set of needs for building reconfigurable optical connections, including devices for spatial optical switching.

Another theoretical study (amplified by careful numerical modeling) was presented by H. Akhouayri, a visiting scientist from the Hassan II University, Casablanca, Morocco; he represented a research group of the University of Marseille, the conference host. This talk concerned the lowering of the bistability threshold by means of resonant-excitation of surface waves. Assuming that a sufficiently formed (undulated) sapphire surface waveguide is available, illumination with TM polarized light can lead to resonant excitation of surface plasmons, which will increase the internal field in the waveguide, and thus, lower the threshold intensity needed for observing optical bistability.

#### Concluding Remarks

Despite some unevenness in the level of the talks this conference was a good one, because, at least in a limited manner, it facilitated interactions between researchers in different fields. Academia and government-sponsored research laboratories were most heavily represented, but industrial research laboratories were also highly visible. The organizers did a fine job: the atmosphere was relaxed and there was plenty of time for informal interactions--provided one could speak French.

## News and Notes

#### REPORT OF FUTURE SENSOR NEEDS OF UK BIOTECHNOLOGY-BASED INDUSTRIES IS NOW AVAILABLE

The results of a survey which examined the future sensor needs of biotechnology-based industries was published in November.

The Sensor Application Center at Warren Spring Laboratory (see page 13 for more on Warren Spring) commissioned the survey. pinpoint areas where new, improved sensors are needed. The survey presents the views of industrial biotechnologists, research and development groups, and equipment manufacturers.

Areas where existing sensors could be made more efficient and cost-effective are highlighted so that industry can capitalize on the information.

The report also includes a literature review of current research and makes recommendations to ensure that sensor provision assists the growth of biotechnology-based manufacturing processes.

The report, "Future Sensor Needs of Biotechnology Based Industries--A Survey," was written by David Rawson and Sarah Gardner, and was edited by Dr. Tony Challoner. It is priced at £50 (about \$80) and is available from Publications Sales, Warren Spring Laboratory, Gunnels Wood Road, Stevenage, Herts SG1 2BX.

C.J. For  
10/23/87

#### MATERIALS RESEARCH IN GÖTEBORG, SWEDEN

Chalmers University of Technology in Göteborg, Sweden, is one of the most active centers of scientific and technological research in the Scandinavian countries. Recently, I had the opportunity to visit the University's Center of Materials Science (CMS), and in particular, the electron microscopy and metal physics group, of which Dr. Gordon Dunlop is the director. The group has many interesting studies in progress, a few of which are described in this note.

#### Carbide and Nitride Precipitates in Steels

A field-ion microscope with atom-probe (AP) analysis has been constructed at CMS. The AP is essentially a time-of-flight spectrometer attached to a field-ion microscope (see ESN 41-7:377-380 [1987]). Surface atoms from the needle-shaped specimens are removed by field evaporation. Atoms with the correct trajectory pass through the probe aperture into the mass spectrograph, where the mass of the atom is determined by time-of-flight (see Figure 1).

L. Karlsson (1986) has used AP to examine needle-shaped specimens of stainless-steel (SS) containing various precipitates (ppt) after a range of heat treatments. Ppt are observed in austenitic SS with 0.5-atomic-percent Ti, Nb, V, C, or N, with heat treatments from 700°C to 900°C. The AP reveals the ppt to be nonstoichiometric with relatively high concentrations of chromium. In this way, Karlsson examined the nature of ppt formed after a range of heat treatments of different specimens of austenitic SS, containing boron additions of 100 ppm.

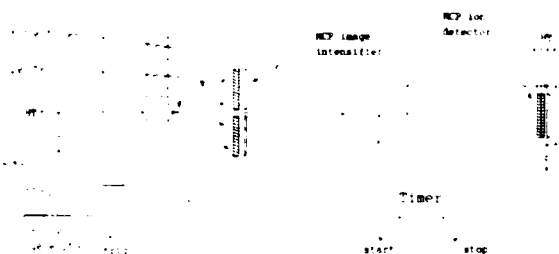


Figure 1. Schematic diagram of the atom-probe instrument.

The AP is an excellent method for permitting the observation of the effects of impurities and additives on the nature and distribution of the ppt.

#### Hydrogen at the Pd/Mg Interface

The absorption of  $H_2$  in Pd and Mg has been examined by A. Kroger and others as part of a project on the hydrolysis of metals for hydrogen storage purposes. Transverse sections of the Pd/Mg interfaces have been examined by transmission electron microscopy (TEM) and electron analytical techniques. Kroger et al. studied the concentration of the hydrogen with respect to the distance it penetrated the Pd/Mg interface. They found that the  $H_2$  is concentrated at the interface with very little in the body of the Mg metal. A stack of Pd/Mg interfaces were prepared, and these confirmed that the  $H_2$  is retained at the interface only.

#### Surface Reaction Chemistry Related to the Reciprocating Engine

B. Kasemo and coworkers are carrying out studies on surface reactions and, in particular, those related to the reciprocating engine. The reactions are carried out in a reaction cell at  $10^{-4}$  to 10 torr, and subsequently the specimen is displaced into an ultrahigh vacuum of  $10^{-9}$  torr for mass spectroscopy and Auger spectroscopic analysis. Kasemo's group investigated several surface reactions including:

- The exothermic catalytic reaction of  $H_2 + O_2$  on Pt
- Oxidation of small C particles and thin C layers
- High-temperature reactions on ceramic surfaces.

#### Surface Studies of Inorganic Biomaterial

Kasemo and his group are also studying the surface structure of inorganic biomaterials using a wide range of electron and x-ray spectroscopic measurements (Kasemo and Lausmaa, 1986). They have

characterized the surface oxides on Ti implants. Surface contaminations on implants can be a problem in use in the biosystem; the bonding to tissue can be affected. Kasemo has studied in detail the surface oxides on Ti implants; traces of F can accelerate oxide growth. X-ray photoelectronic spectroscopy scans of C and O peaks give information about the chemical state of the surface. The shape of the O peak gives indirect evidence about OH and  $H_2O$  at the interface.

#### Other Studies

An idea of the active nature of the electron microscopy group can be obtained from the wide range of their ongoing studies; these include:

- Superplastic deformation of ceramic materials
- Precipitation reactions in stabilized austenitic stainless steel
- Fine-scale microstructure of high-speed steels
- Transformations in hard metal binder phase alloys and creep of hard metals
- Precipitation and creep in high-conductivity Cu-Cr alloys
- The influence of Fe and Cr on the microstructure of cast Al-Si-Mg alloys
- Formation of intermetallic compounds during solidification of dilute Al-Fe-Si alloys
- The microstructure of rapidly solidified Al-5Mn-2Cr
- Development of microstructure in age hardening cast Mg alloys
- Development of microstructure during fabrication of  $Si_3N_4-ZrO_2$
- Partially stabilized  $ZrO_2$
- Oxidation of  $\beta-Si_3N_4$  ceramics
- The role of microstructure in ZnO varistor material.

#### The National Context for CMS Work

While the studies at CMS are related to and have significant technological importance, they are pursued as basic studies. This relates to the very sensible collaboration in Sweden between university and industry. This is helped and encouraged by the Swedish National Board for Technical Development (STU). At STU, material research is covered by the Industrial Processes Department, headed by P. Forsgren; metallic materials are covered by K. Klarin, ceramic materials by C.O. Frykfors, and polymers and composites by K. Lindman. A recent meeting of the STU committee on Engineering Ceramic prepared a new 5-year plan for research studies in Sweden, involving many of the major industrial companies such as Volvo, Sanvik Hard Materials AB, Kema Nord Industrikemi, Asea-Cerama, AB, with the universities in Göteborg and Stockholm.

Also located in Göteborg is the Swedish Institute of Silicate Research, and near the university campus, there is a developing industrial research park. Many of the Swedish scientists have worked in the US and are completely familiar with US practices. Scientific meetings in Sweden are usually in English, though their meetings are not generally well known. Several meetings on materials science are planned for 1988, and details of these will be published as far as possible in advance (as in item below) ESNIB and other ONRL publications.

#### References

- Karlsson, L., *Segregation and Precipitation in Austenite Stainless Steels* (Doctoral Thesis, Chalmers University of Technology, 1986).
- Kasemo, B., and J. Lausmaa, "Surface Science Aspects on Inorganic Biomaterials," *CRC Critical Reviews in Biocompatibility*, 2 (1986), 335-380.

Louis Cartz  
10/7/87

#### MEETING ON COMPOSITE MATERIALS IN SWEDEN, March (1988)

The Swedish Society for Materials Technology and the Center for Materials Science, Chalmers University of Technology, are organizing a meeting to be held on 15 and 16 March 1988 on Composite Materials. The meeting will be located at the Chalmers University of Technology, Göteborg, Sweden. The language used at the meeting will be English.

The program will cover important aspects of the science, technology, and engineering applications of composites. As of this date, invited speakers include:

- T.W. Clyne, Cambridge University, UK, "Metal Matrix Composites"
- A.R. Bunsell, Ecole des Mines, Evry, France, "Structure and Properties of Advanced Fibers"
- D.B. Marshall, Rockwell Science Center, US, "Ceramic Matrix Composites"
- T. Mäntylä, University of Tampere, Finland, "Creep of Metal Matrix Composites"
- R. Talreja, Technical University of Denmark, Lyngby, Denmark, "Fatigue Damage in Polymeric and Ceramic Matrix Composites"

As indicated by the list of invited speakers, and because of the quality and current concentration of effort in Sweden on materials research, this meeting promises to be particularly interesting.

Further details can be obtained from Dr. G.L. Dunlop, Professor, Center for Materials Science, Chalmers University of Technology, 5 Fysikgränd 3, S-41296, Göteborg, Sweden. Telephone Int +46-31723307; Telefax Int +46-31-165178.

Louis Cartz  
10/1/87

#### MECHANICAL TESTING OF ENGINEERING CERAMICS AT HIGH TEMPERATURES

A meeting will be held on the mechanical testing of engineering materials at high temperatures in London, UK, on 11 and 12 April 1988, at the Excelsior Hotel, London Heathrow Airport.

This meeting is being organized by the UK High Temperature Mechanical Testing Committee in collaboration with the Institute of Ceramics (UK). Since the measurement standards in the field of engineering ceramics are only now being developed, the purpose of this meeting is to review test equipment and methods and to establish international standards, and it is therefore of significant interest to all those concerned with engineering ceramics. The conference will consist of a series of invited papers, and also a poster session for which contributions are sought--they will be acceptable up to time of the meeting.

Further details can be obtained from Dr. B.F. Dyson, Conference Chairman, Division of Materials Applications, National Physical Laboratory, Teddington, Middlesex TW11 0LW, UK. Telephone 01-943-6519; Telex 262344.

Louis Cartz  
10/23/87

#### HYDRAULICS AND FLUID MECHANICS RESEARCH AT ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

The Ecole Polytechnique Fédérale de Lausanne (EPFL), located in Lausanne, Switzerland, has an enrollment of more than 2300 and a staff of approximately 1500 professors, assistants, technicians, and administrators. It is one of two

federal institutes of technology in Switzerland, the other being the Eidgenössische Technische Hochschule (ETH) in Zürich.

This article reports on a visit to EPFL's Institute of Hydraulic Machinery and Fluid Mechanics headed by Professor I.L. Ryhming. Professor Ryhming is well known for his contributions to fluid mechanics. He has had wide academic, industrial, and administrative experience in his native country of Sweden (where he was the chief scientist of the Aeronautical Research Institute of Sweden [FFA]), in the US where he worked for the Boeing Company, General Dynamics, and the Aerospace Corporation, and in Switzerland where he served as scientific director of the Institut CERAC.

The Institute for Hydraulic Machinery and Fluid Mechanics has a scientific and technical staff of approximately 45 and is located on two sites: the hydraulic research facilities in the original buildings in the center of Lausanne, and the fluid mechanics research facilities on the new (since 1976) campus in Ecublens approximately 5 km west of the downtown site. Both laboratories impressed me as being among the most modern, well equipped, and aesthetically pleasing facilities I have seen in Europe and bear clear witness to the success which Ryhming has had in obtaining support for this research activities both from the government and from Swiss industries.

#### Hydraulics Research

The showpiece of the hydraulics laboratory is the newest and most modern cavitation tunnel in Europe; it was commissioned in February 1986. Most of the 1.1 million dollars required for its construction was obtained from a consortium of Swiss hydraulic turbine manufacturers with smaller amounts of support coming from various Swiss organizations including the Swiss National Science Foundation. The test section is approximately  $15 \times 15$  cm<sup>2</sup> and 45 cm long. The maximum velocity is 50 m/s, and the tunnel can be pressurized up to 15 bars. The tunnel is equipped with high-intensity lighting for flow visualization and a computer-controlled LDA system.

The money-making side of the operation is doing performance testing for hydraulic turbine manufacturers. In fact, EPFL has one of only three such facilities in the world. At present there are two test stands capable of absorbing approximately 500 hp. A third test stand is currently being designed. The facility is directed by Professor P. Henry and is staffed by two professors, three Ph.D.-holding assistants, four engineers, and numerous technicians.

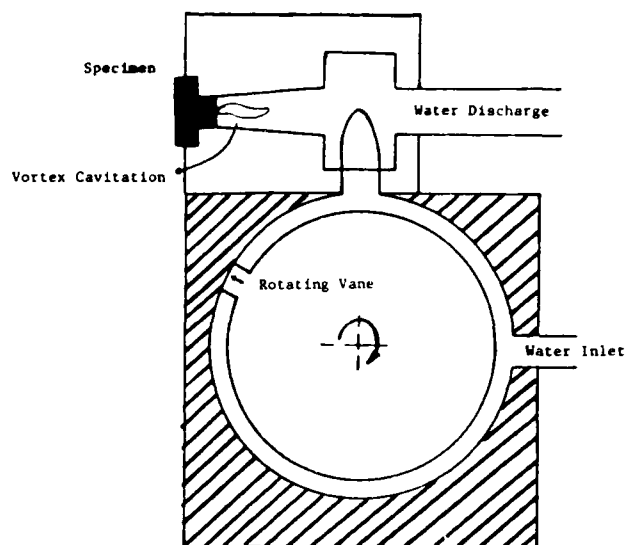


Figure 1. Vortex chamber.

Cavitation is an area in which the laboratory has a very active research program. Ryhming believes that he has discovered a new cavitation mechanism involving vortex bursting in which a vortex element shed by a cavitating blade is swept downstream and implodes on a following blade or the turbine casing. This is different from ordinary bubble collapse because of the presence of vorticity. He has developed a device for producing such vortex implosions (see Figure 1) and in collaboration with the physics department is using a scanning electron microscope and a Cranz-Schardin chronolens system to investigate the cavitation damage and the manner in which it occurs.

On the main campus are research facilities for doing shock wave, three-dimensional boundary layer, and boundary layer manipulation studies. It is operated by a staff of approximately 25 professors, assistants, research students, and doctoral candidates. The newest of these facilities is the three-dimensional boundary-layer tunnel built with EPFL funds in which benchmark data will be taken in a  $1.5 \times 0.4$  m<sup>2</sup>, S-bend test section to develop and validate various three-dimensional boundary layer codes and instrumentation. This work is being done in conjunction with the Euroexpt working group on three-dimensional boundary layers.

#### Fluid Mechanics Research

In 1981, using the laboratory's  $0.76 \times 0.12$  m<sup>2</sup> low-turbulence wind tunnel, Ryhming conducted one of the first



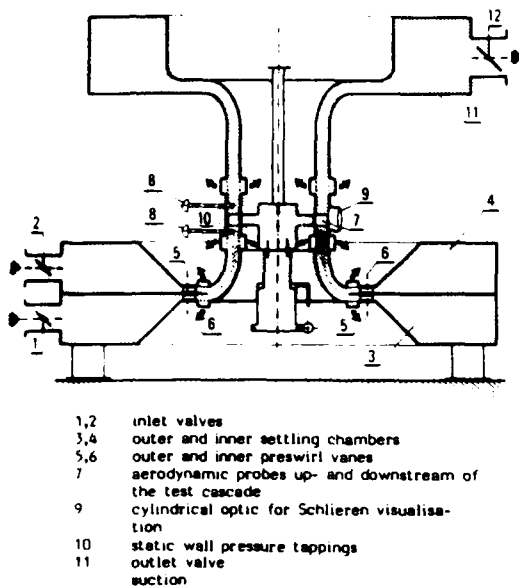


Figure 2. Annular cascade facility.

European experiments on boundary layer manipulation as a mechanism for drag reduction. Although the facility is not capable of producing conditions approaching either ship or aircraft applications ( $3 \times 10^6/m$  being the maximum Reynolds number obtainable), the data collected thus far has provided insight into the understanding of such devices. Recent work in this area was reported at last year's meeting on turbulent drag reduction in Lausanne (ESN 41-2:87-91 [1987]).

Although not under Ryhming's direction, the new campus is also the site of the Laboratoire de Thermique Appliquée et de Turbomachines where gas turbine research is being conducted under the direction of Professor Albin Böls. Their principal facility is a new (1983) annular cascade facility for studying steady and unsteady transonic flows in both turbines and compressors (see Figure 2). For flutter testing, each of the 20 blades of the 400-mm-diameter cascade can be independently driven in both bending and torsion at selected levels of frequency, amplitude, and interblade phase angle. The flow diagnostics include two traversing pressure probes, pressure taps, and a high-speed cylindrical schlieren system.

#### Conclusion

The cavitation and three-dimensional boundary layer studies being conducted at EPFL are relevant to many of the Navy's research programs. Ryhming has excellent facilities, and the number and quality of his publications and those of his col-

laborators attest to his skills in research and scientific management. His connections with the US fluid mechanics community through his work experience and his exposure to the US Navy's needs obtained from his recent visits to Navy facilities and contractors through ONRL's Visiting Scientist Program make him and his laboratory excellent prospects for future Navy research collaborations.

S.F. Brown  
Virginia Polytechnic Institute and  
State University  
George S. Dulikravich  
Pennsylvania State University  
8/26/87

#### OCEANOGRAPHY: INSTITUT FRANCAIS DE RECHERCHE POUR L'EXPLOITATION DES MERS (IFREMER)

The French oceanographic agency, Institut Francais de Recherche pour l'Exploitation des Mers (IFREMER), has a total of five major facilities in France, including its headquarters in Paris, but the largest--the one I visited--is located on the coast of Brittany near Brest. The Brest laboratory (Centre de Brest) has a total staff of about 650 people working in the areas of ocean sciences; technological research, development, and testing; instrumentation; and data processing. It has facilities for all these purposes. The instrumentation calibration capability for the calibration of salinity, temperature, pressure, and water flow sensors is of high quality, so that Brest is the French center for oceanographic instrumentation standardization. Also available are a number of high-pressure test tanks including a 2500-bar tank, a 1000-bar tank, and a number of lesser capability chambers. These are used to examine corrosion under pressure and the fatigue effects of pressure cycles, among other things.

#### Other Major IFREMER Facilities

In contrast to the Brest facility are the labs at Boulogne-sur-mer and Nantes that highlight mariculture and fisheries and the Toulon center where work in underwater operations and deep-sea technology is carried out. There is also a marine center in Tahiti where fisheries and aquaculture techniques are being studied, along with ocean thermal energy conversion (OTEC) methodologies. In addition to these land-based facilities, IFREMER operates a fleet of 12 surface research vessels, six of which are

large enough for extended ocean cruises; two manned deep-sea (3000 and 6000 meters) submersibles; and one 6000-meter unmanned submersible.

#### IFREMER Programs

Major IFREMER programs fall into three general categories: industrial research and development, living resources, and environmental and ocean research. Industrial R&D includes undersea technology, ocean floor mining studies, OTEC, and marine engineering and architecture. Work within the general area of living resources is concerned with the development of fishery and fish processing methods, fishery management (both from the economic and fish population points of view), mariculture, and sanitary control. Geophysics, geology, geochemistry, physical oceanography, coastal zone management, and deep-sea ecology are all considered to fall within the confines of environmental and ocean research.

#### Centre de Météorologie Marine at Brest

Also located at IFREMER-Brest is the Centre de Météorologie Marine (CMM), a branch of the French Meteorological Office. A staff of 10 meteorologists occupy about 3000 square feet of office and lab space and are primarily concerned with acquiring and interpreting marine meteorological data. Consequently, they are heavily involved with ocean buoys. Both drifting and fixed buoys are used, not only for synoptic data but also to supply "sea truth" for various satellites. Typically, atmospheric pressure is the most common parameter measured, but wind speed and direction, air and surface water temperature, and water temperature profile can also be obtained. Some R&D on future buoys and their instrument suites is in progress.

#### COB: Physical Oceanography Division

The Physical Oceanography Division numbers about 30, of whom 10 are professionals and the rest are support personnel. Their work includes projects in acoustic tomography, circulation studies, numerical modeling, marine chemistry, coastal and bottom processes, the use of SPOT images in coastal regions coupled with "sea truth" studies, and a study of the mixed layer. I spoke with Yves Desaubies, who described some of these programs to me. He heads up the acoustic tomography group at Brest, and is actively cooperating with a similar group at Woods Hole Oceanographic Institute (Massachusetts). The Brest group tested a new tomographic instrumentation suite in the Mediterranean last spring, and they plan another test off the coast of Portugal at the end of the summer with three

new related instruments. A number of modeling and simulation studies are proceeding in conjunction with these field studies to more accurately specify instrument parameters such as placement, geometry, configuration, sensitivity, density, etc. A large experiment, in conjunction with a number of American groups, is planned for the fall of 1988 when it is hoped that a series of new instruments can be used in the Gulf Stream region.

Other projects in physical oceanography include a cooperative project with the University of Kiel (West Germany) in which an attempt is being made to assess the bottom topographical effect of the Mid-Atlantic Ridge on North Atlantic residual currents. In conjunction with the National Center for Atmospheric Research (Boulder, Colorado) a numerical model, consisting of both coarse and finer nested components, is being developed for use in the forthcoming World Ocean Circulation Experiment. Working with the CMM, mentioned above, buoys are being developed to aid in calibration of the ERS-1 wind sensor, and then later to supply "sea truth" as the satellite becomes operational. Lastly, the surface mixed layer is being studied to develop a relationship between sea-surface temperature and hydrodynamic phenomena. Field data are being obtained by the use of drifting buoys.

#### Conclusion

The IFREMER facility at Brest is the largest marine-oriented laboratory in France. It is well equipped and well staffed, and the work being done there is innovative and of high quality. However, as indicated in its name, the objective of the Brest laboratory is to perform research directed toward increasing the exploitation of the oceans. Consequently, the work done here is applications oriented, as evidenced by the fact that the scientific staff (the staff occupied in basic oceanic research) numbers only five percent of the total. This scientific effort, while certainly respectable, is generally not unique and most of it is being performed in conjunction with other groups, mainly American. It would seem that science plays more of a support role at Brest, while the major French effort in marine science is centered in Villefranche-sur-mer near Nice where the CNRS Laboratory de Physique et Chimie Marines is located. A description of a visit to this laboratory appeared in the first issue of the *European Science Notes Information Bulletin* (ESNIB 87-01:45-47 [1987]).

Jerome Williams  
9/15/87

# NEW INTERNATIONAL ADVANCED MULTIDISCIPLINARY THEORETICAL STUDY-INSTITUTE ANNOUNCED

Formation of the International Institute for Advanced Scientific Studies (IIASS) has been recently announced in Naples (Italy). Its director is Professor E.R. Caianiello (Salerno University), and the Scientific Council consists of 13 well-known theoretical physicists, including two Nobel laureates. The essential purpose of the institute is the creation of a center in the south of Italy that assumes the same role and functions--international forum for interdisciplinary exchanges, and tutorial-educational facilities for developing countries--as the well-known International Center for Theoretical Physics, Trieste, in the north of the country. IIASS plans to place major emphasis on the following areas:

- Nonlinear phenomena with focus on parallel computing and solitons
- Cybernetics and Artificial Intelligence--especially in robotics, sensors and their coordination, image analysis, neural networks, human-machine interfaces, teaching machines.

Apart from coordinating research, courses, seminars, meetings, and workshops will also be organized by IIASS.

Apparently, interest from overseas, has been expressed by the Commission of Independent Colleges and Universities (CIS), and the International Center for Physics, Bogotá.

Enquires may be directed to IIASS, Via Vittoria Colonna 14, I-80121 Napoli, Italy.

Paul Brown  
1987

## STRUCTURAL EFFECTS IN AMORPHOUS FERROMAGNETS--AN ONRL-SUPPORTED CONFERENCE SESSION

From 25 to 29 May 1987 the Autonomous University of Madrid and the Spanish Research Council conducted a highly topical Symposium on Magnetic Properties of Amorphous Metals. The meeting, attended by both European and American scientists, took place in a conference center near Malaga. While a number of American participants received US Navy support from the Naval Surface Weapons Center, the London Branch Office of ONR undertook the support of four European scientists,

whose talks constituted a special session entitled Structural Effects in Amorphous Ferromagnets. Following are the highlights of these four talks--abstracts of the entire Symposium may be requested from Dr. H. Savage, Code 115, NSWC, White Oak, Maryland 20903-5000.

J.A. Leake (University of Cambridge, UK) pointed out that magnetic properties can be particularly sensitive indicators of the state of relaxation of amorphous metals. He then presented a review of the principal experimental results, with emphasis on magnetic properties such as coercive field, Curie temperature, magnetostriction, and field-induced anisotropy. Care was taken to distinguish between reversible and irreversible structural relaxation and stress relaxation. Leake showed that the correlation between the kinetics of change of different properties provides useful additional information about the nature of the relaxation processes, as do variations between glasses of related compositions. Subsequently, he outlined the various theoretical models that have been advanced to explain these observations, and emphasized that the Activation Energy Spectrum Model is particularly useful. Separate, broad Gaussian spectra are needed for the reversible and irreversible processes. Finally, Leake presented descriptions of possible atomic rearrangements, and related these to activation energy spectra.

Laboratory-scale production of soft-magnetic wide amorphous tapes formed the topic of the talk by A.R. Yavari (National Polytechnic of Grenoble, Saint Martin d' Hères, France). He reminded the audience that while metallic glasses can be obtained by a variety of techniques, rapid solidification via liquid quenching remains the most convenient and versatile procedure for producing alloys which form glasses easily, including soft-magnetic Fe-B type amorphous alloys. Unfortunately, melt-spinning, splat-quenching, and other varieties of liquid-quenching techniques produce small quantities of glassy alloys or, at best, narrow continuous ribbons. But a recently invented procedure known as planar-flow-casting (PFC) allows the preparation of wide amorphous tapes directly from the liquid state. Yavari explained in detail how PFC can be performed efficiently on a laboratory scale. Next he showed how, depending on the choice of experimental parameters, the thickness of the tape product can be controlled and how for most Fe-B alloys these conditions must be chosen not only to avoid critical thickness of the onset of crystallization, but also thickness limits beyond which the as-quenched ribbon is brittle. All mechanical aspects

and experimental conditions that determine quench-rate have an effect on both the as-quenched state of the soft-magnetic properties and on the extent to which they can be improved with processing and relaxation annealing.

F. Vinai (National Electrotechnical Institut, Torino, Italy) described cooperative research regarding losses, after-effects, and disaccommodation in amorphous ferromagnetic alloys. He commenced by observing that in metallic glasses different macroscopic parameters are affected by the intrinsic metastability of the amorphous lattice. He then showed that, specifically, the permeability aftereffect is a reversible relaxation of the magnetic permeability, strictly connected with the structural properties of the amorphous alloys. The permeability relaxation changes in a similar way either by modifying the stresses frozen in the material during the solidification process by thermal treatments, or by applying suitable tensile stresses. Vinai told the meeting that by extending the time interval in which the aftereffect can be measured down to very short times after impulsive demagnetization, one finds a new relaxation effect of the magnetic permeability. This phenomenon is related to rearrangement of the domain wall structure subsequent to the impulsive demagnetization. This process of relaxation is due to a variation with time of the energy dissipation of the system connected to a change of the number of active walls, or to bowing effects. On the other hand, it is possible to show the existence at short times of a tail of the diffusional aftereffect, probably connected to the same processes which are responsible for the permeability relaxation usually measured at longer times after demagnetization. The preliminary analysis of this phenomenon suggests the existence of correlations between defects giving rise to the permeability aftereffect, Vinai concluded.

The fourth talk, given by G. Herzer (Vacuumschmelze GmbH, Hanau, West Germany), fitted somewhat loosely into the proceedings. He discussed industrial applications of metallic glass ribbons. Herzer explained that candidates for applications are, first of all, Fe-rich magnetic alloys which exhibit the highest saturation flux densities among the amorphous metals and are based on inexpensive raw materials such as Fe, Si, B, and C. The Co-based metallic glasses, on the other hand, are distinguished by their low or vanishing magnetostriction, leading to extremely high permeabilities and very low magnetic losses. Herzer then gave a survey of major current applications of ferromagnetic metallic glass

ribbons in the electronics industry. In particular, he discussed the following topics: magnetic cores with low losses and specifically designed hysteresis loops for inductive components in switched-mode power supplies or in magnetic switches for pulse compression in power sources; magnetic heads for audio and video recorders; flexible magnetic shieldings; robust and reliable magnetometers; and sensitive displacement or torque transducers.

Paul Roman  
9/17/87

ONR-LONDON HAS SPONSORED A CONFERENCE  
SESSION ON UNUSUAL APPLICATIONS OF AD-  
VANCED MOLECULAR SPECTROSCOPY

A NATO-Advanced Study Institute (NATO-ASI) meeting on Frontiers of Laser Spectroscopy of Gases was held at Vimeiro (Torres Vedras), Portugal, 30 March to 10 April 1987. The codirectors of the school and conference were Dr. J.M. Hollas (Reading University, UK) and Professor A.C.P. Alves (University of Coimbra, Portugal). The meetings were attended by 104 participants, including 14 lecturers. Most participants came from the UK, West Germany, and Portugal (in that order); there were only 10 scientists from the US.

During a day's break in the school's meetings (April 2), the participants of the NATO-ASI were transported to the ancient university town of Coimbra, where, following a ceremonial session, a festive scientific session entitled Unusual Applications of Advanced Molecular Spectroscopy took place. This session, consisting of invited talks only, was fully sponsored by the Office of Naval Research Branch Office, London. Following is a brief summary of the talks given at that session.

Professor A. Carrington (Oxford University, UK) presented his very recent research results in the area of spectroscopy of molecular ions and their dissociation limits. He and his colleagues studied the vibration-rotation spectra of the  $H_2^+$ ,  $HD^+$ ,  $D_2^+$  and the  $H_3^+$  ions involving levels close to dissociation limits. Carrington used ion beam methods. Contrary to their previous results on  $HD^+$  (which determined only differences in nuclear hyperfine splitting between the lower and upper vibrational levels), the scientists were now able to detect weak satellite lines which can yield absolute

values of the deuteron hyperfine constants. Carrington then described further, current experiments designed to detect nuclear hyperfine radiofrequency transitions in  $\text{HD}^+$ . In regard to the  $\text{H}_3^+$  research, Carrington reported the discovery of an extremely dense infrared predissociation spectrum. Proof was found of many highly metastable vibration-rotation levels embedded in the continuum. Finally, the speaker presented a model for describing the  $\text{H}_3^+$  molecule above the lowest dissociation limit.

Professor I.M. Mills (Reading University, UK) talked about the interpretation of vibrational overtone spectra and combination state spectra which were observed by Fourier transform spectroscopy and also by laser photoacoustic spectroscopy in polyatomic molecules. First, Mills discussed the interesting experimental techniques that he used. Then he reviewed the effects of bond dissociation anharmonicity in a diatomic molecule. Next, he introduced the concept of "local modes," which are central to his analysis. Eventually Mills arrived at a mathematically well-defined quantum mechanical model. He discussed this model in detail for the case of two symmetry-related stretching vibrations (such as in  $\text{H}_2\text{O}$ ). Subsequently, he described his and his colleagues very recent work on the dichloromethane molecule, and fits to the overtones of carbonyl stretching vibrations in metal carbonyls. He concluded his talk with comments on the implications of the research done for intramolecular vibrational relaxation and, more generally, for chemical dynamics.

The last talk in the special session was delivered by Professor Dr. G. Winnewisser (University of Cologne, West Germany), and it dealt with a very unusual and exciting topic: interstellar masers and star formation in the galaxy. Four molecules ( $\text{H}_2\text{O}$ ,  $\text{SiO}$ ,  $\text{CH}_3\text{OH}$ , and  $\text{OH}^+$ ) among the over 75 species now known to exist in interstellar space exhibit strong maser action. In addition, several others (such as  $\text{NH}_3$  or  $\text{H}_2\text{CO}$ ) show weak maser action or at least have population inversion. Such molecular masers can serve as important signposts for star formation taking place in molecular clouds. In order to make this subject accessible to a broader audience, Winnewisser first presented an overview of relevant astrophysical topics (such as composition and chemistry of interstellar clouds, the galactic structure and the distribution of neutral matter, the mass loss from evolved stars, and the general dynamics of molecular clouds.) This was followed by a careful discussion of the maser characteristics, and of how the interstellar masers can be used to extract

astrophysical information. Finally, Winnewisser described his newly developed model with which it is possible to understand details of the recently discovered bipolar molecular outflow associated with the birth of young stars.

The proceeding of the entire 12-day meeting have been published in the familiar NATO-ASI Proceedings Series and may be ordered through the usual distribution centers.

Paul Roman  
9/17/87

#### AN INTERNATIONAL OPTICS EXHIBITION IN MADRID

The 6th Expo/Optica Exhibition and meeting in the field of optical and acoustical technology, optometry, and electro-optics was held in Madrid, Spain, at the modern premises of the Madrid Trade Fair Organization (IFEMA) from 24 through 27 April 1987. This is a recurring Spanish affair, organized by Spanish industrial, educational, and commercial organizations and firms, and, despite its strongly commercial nature, is also a scientific channel of communication--at least for marketable developments in R&D. The organizers take pride in pointing out that "times have changed, and today, in some fields, we [Spanish] are achieving growth levels on a par with those of our neighbors in the European Community." I truly agree with this self-assessment.

Unfortunately, the talks and conferences were restricted to rather narrow commercial problems or product-promotion presentations, so that I report only on some highlights of the exposition itself.

There were over 300 stalls, mostly Spanish, but 16 foreign countries were also represented. The fields covered (and neatly grouped in the exhibition halls) were:

- Optics and optometry
- Electroacoustics and audiometry
- Optronics and electro-optics
- Technical publications.

The majority of the exhibits were in the optometry and medical optics area (disappointing for me, of course) and I pick now only a few representative firms which, I believe, have products or current developments that may interest readers of *ESNIB*.

Bobes S.A., Madrid, demonstrated good capabilities in night vision equipments, especially in the military field of applications. It also has high-precision lens-fabrication technology, and produces inexpensive but solid and versatile optical teaching equipment.

Cualicontrol S.A., Madrid, displayed (among other lines) fine equipment for the microelectronics industry (including photolithography and UV-writing automatics) as well as general optical equipment (multipurpose microscopes, periscopes, autocollimators, optical separators). Optical benches and laser technology accessories are also in their field.

Indo, Barcelona, appears to be a fast-upcoming firm in lenstechnology and optometrics.

Optic's, a Barcelona-based applied optics development institute and manufacturer, displayed an impressive range of Newton reflector telescopes (the ones with highest luminosities and greatest image-definition had apertures between 158 mm and 255 mm.) Automatic tracking facilities are available.

Among the non-Spanish exhibitors, I want to note, prominently, the French optoelectronics firm Angénieux (St. Héand.) Infrared (IR) optics and imaging, especially in the 8- to 14- $\mu$ m window, seem to be their forte. IR lenses with diamond or amorphous carbon coating gave the firm high recognition. Fabrication of aspherical elements is another of their specialities. They also pride themselves with having developed the world's smallest (visible range) CCD TV-camera, as well as the world's largest IR (8 to 13  $\mu$ m) zoom camera objective.

The Italian development firm Enea (Rome), which systematically transfers its research results to Contek s.r.l. (at Varallo Sesia), displayed a number of fascinating optical systems. To me, the most interesting ones were: beam shape correctors, double-reflection beam collimators, beam integrators (convex beam dissector plus concave focusing reflector), wire polarizers, and LIDAR telescopes. (They were quite reticent about the latter, and displayed only a brief poster.)

Not unexpectedly, several Japanese firms also made their appearance, via various European representatives. Hamamatsu Photonics K.K. lead the field. Their beautiful and substantial "product guide" booklet boasts that it introduces "the world's most complete line of photonic devices and systems." I did indeed find products from all areas of optoelectronics; but my main interest converged on streak cameras for GHz phenomena, and on equipment for waveform measurement over 30 GHz. However, closer ques-

tioning did not yield much specific information.

I have documents of most of the described products, as well as a catalog of the entire exhibition, and would be glad to share these with colleagues, provided their queries are sufficiently specific.

In summary, I should say that attending the show proved useful (since I was in Madrid in any case) but I would not recommend specific trips to future repeat-exhibitions.

*Paul Roman*  
4/15/87

#### UK ESTABLISHES JOINT COMMITTEE TO SUPPORT DEVELOPMENTS IN SUPERCONDUCTIVITY

The UK's Department of Trade and Industry (DTI) and the Science and Engineering Research Council (SERC), formed a joint committee in October 1987 to co-ordinate support for developments in superconductivity.

Chaired by Sir Martin Wood (Oxford Instruments), the committee will include representatives from industry, academia, and government, and will have responsibility for advising both SERC and DTI on national research and development priorities in an effort to boost the UK effort.

Both DTI and SERC have supported research and development in conventional superconducting technology for many years, although recent developments have led to a reexamination of needs in this area. The potential advantages of superconducting materials at room temperature are, of course, enormous, and one of the first tasks, therefore, will be to help select the location of the University Research Center for Superconductivity. The committee will also assess national education and training needs.

In order to further encourage industrial/academic collaboration and keep in close touch with developments abroad, the DTI and SERC have appointed Dr. Ian Corbett as the UK's Joint Coordinator for Superconductivity. He is Head of the Applied Science Division at the SERC Rutherford Appleton Laboratory, and part of his role will be to ensure that industry and academia are well informed about the policies of the national committee for superconductivity.

*C.J. Fox*  
10/23/87

ONRL COSPONSORED CONFERENCES

Scientific Director, ONRL, Box 39, FPO  
New York 09510.

ONR, London, can nominate two DOD employees for registration-free participants in the conferences ONRL supports. Readers who are DOD employees and are interested in a free registration to one of these conferences should write to the

Assembly and Dynamics of the Cyto-matrix, Maria Alm, Austria, March 1988.

Second Conference on Hyperbolic Problems, Aachen, West Germany, March 1988.

Structure and Function of the Cyto-skeleton, Lyon, France, April 1988.

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ONRL REPORTS

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONR, London.

Behavioral Sciences

*The 33rd International Applied Military Psychology Symposium*, by William D. Crano. (7-033-C) Selected presentations given at this meeting held in June 1987 at Lisbon, Portugal, are summarized. Topics under which they are presented are: the relevance of psychology to the military; factors that affect retention of military manpower; stress and reactions to extreme conditions; selection; organizational development; and technology and technology transfer.

Biological Sciences

*Conference on Surfaces of Biomaterials Biotechnology--Biointeractions '87*, by Claire E. Zomzely-Neurath. (7-032-C) Presentations given at this conference, held in July 1987 in Cambridge, UK, are discussed. The conference was focused on the ways in which biotechnological products and man-made materials interact physically and chemically with biological environments. Topics of the programs were: cell/polymer interactions, blood/surface interactions, innovations-monoclonal antibodies and biosensors, biocompatibility, bioadhesions, and drug delivery systems.

Material Sciences

*A Joint UK-West German Meeting Discusses Advanced Engineering Ceramics*, by Louis Cartz. (7-029-C) Silicon nitride ceramic properties discussed at this meeting in April 1987 included sintering in the presence of silicon oxynitride glass, gas pressure sintering, oxidation problems, and reactions with silicon carbide. Silicon oxynitride glasses are shown to be inherently transparent.

*Assessment of Electroceramic Research in Europe and the Middle East*, by Robert W. Vest. (7-028-R) European/Middle Eastern research in microelectronics is discussed under four topic areas: dielectronics, sensors, hybrid microelectronics, and non-conventional processing.

*Second NATO Workshop on Passive Infrared Optical Materials and Coatings*, by Robert W. Schwartz. (7-031-C) Discussion of the presentations given at this workshop is organized under the following topics: bulk materials--windows, bulk materials--internal components, bulk materials characterization, hard coatings, anti-reflection coatings, and characterization of coatings.

Mechanics

*European Reacting Flow Research: A Final Assessment*, by Eugene F. Brown. (7-027-R) The author provides a sampling of combination research activities in Europe, with emphasis on the work in France, West Germany, and the UK. He states that there is a great deal of diversity in the projects, and in most cases there is strong industrial support. He also reports on the important new European initiatives--the European Communities Combustion Research Program and the European Center on Flow, Turbulence, and Combustion Simulation.



*AGARD--The NATO Advisory Group for Aerospace Research and Development*, by CDR Dennis R. Sadowski. (7-025-C) The AGARD origin, mission, organization, and list of AGARD Panels is presented in this brief summary of an important aerospace advisory body.

*Highlights of the 20th Flight Mechanics Panel Symposium on Flight Vehicle Development Time and Cost Reduction*, by CDR Dennis R. Sadowski. (7-026-C) Selected presentations given at this meeting, held in May 1987 in Toulouse, France, are reviewed. Topics of the papers include cost estimating, use of CAE-CAD-CAM, prototype manufacturing, and computer-integrated manufacturing.

*International Conference on Industrial and Applied Mathematics*, by Eugene F. Brown. (7-030-C) This conference, held in July 1987 in Paris, France, gave clear evidence of the contribution of applied mathematics to the field of computational fluid mechanics, particularly in the fields of discrete vortex methods, multigrid methods, and lattice gas hydrodynamics. Selected presentations are reviewed.

#### OVERSEAS TRAVELERS

Notes on trip reports to locations in Europe and the Middle East which have been received by ONRL are reported below. For details, contact the traveler directly.

##### Astronomy

*Travelers: Dr. Jules Aarons, Research Professor, Department of Astronomy, Boston University, Boston, Massachusetts 002215.*

Dr. Aarons attended the AGARD Electromagnetic Wave Propagation Panel Symposium on Scattering and Propagation in Random Media, which was held in May 1987 at the Italian Air Force Base in Lago di Bracciano, Italy. Aarons delivered a paper on studies being performed under ONR support. The title of the paper, coauthored with A.S. Rogers of the British Antarctic Survey, was "Magnetic Stems Effects on F Layer Irregularities Near the Auroral Oval."

Of the other papers given at the symposium, many were concerned with scattering from objects and scattering in the lower atmosphere. However, several sessions were concerned with recent results in ionospheric scattering.

The paper by Professor A. Hewish of Cambridge University, a Nobel Prize winner, was, in essence, the presentation of pilot studies for a larger program, the concept of which is to use the powerful astronomical technique and equipment of radio astronomy interferometry that is already in place at Cambridge University to determine the parameters of the solar wind.

Aarons also visited Cambridge, in the UK, for a working session with the people at the British Antarctic Survey. While in Cambridge, he talked with Professor Hewish, who is of the opinion that the sources of both magnetic storms and proton events are coronal holes. Aarons says that this is disputed by many, and therefore Hewish's concepts are often the subject of vigorous debate; he also said that these ideas and sources should not mask the potential of the proposed program for continuous observations of the solar wind. Hewish has obtained support for the program both from the UK and NOAA.

##### Chemistry

*Travelers: Dr. Ronald L. Archer, Professor of Chemistry, University of Massachusetts, Amherst, Massachusetts 01013.*

Dr. Archer attended the Seventh International Symposium on the Photochemistry and Photophysics of Coordination Compounds, held in April 1987 at Schloss Elmau, West Germany.

The report comprises a brief survey of the presentations, which ranged in the first session, for example, from a paper on a study of a series of orthometallated ligands with a series of platinum metal ions to Dr. Archer's own study of the extreme radiation sensitivity of heavy metal chelate polymers for potential use as gamma or electron beam IC chip lithographic resists.

The second session featured results with organometallic photochemistry, and the third session began with several elaborate studies of ruthenium (II) diimine photochemistry and chemistry. The final day was made up of contributions on miscellaneous aspects of the photochemistry and photophysics of coordination compounds.



Archer reports that, overall, the feeling at the meeting was one of excitement over new advances in both theory and in practical applications, and with general agreement that only the "tip of the iceberg" has been uncovered in this field to date. Details of the conference will be published later this year by Springer Verlag.

*Invited:* Dr. Itmar E. Dengel, *Energetics Materials Division, Naval Surface Warfare Center, Dahlgren, Virginia 22448-5000.*

Dr. Dengel's purposes for visiting West Germany in early July 1987 were: (1) to discuss cooperative efforts in the area of numerical analysis of underwater explosions and underwater warhead technology at IABG/TFF, Ottobrunn; (2) to discuss twin-screw processing of explosives/propellants at Werner Pfleiderer, Stuttgart; (3) to discuss a draft DEA on underwater explosions and underwater warhead technology at the West German Ministry of Defense, Bonn; (4) to present a paper at the 18th International Conference of ICT, Karlsruhe; and (5) to observe continuous processing of double-base propellants at Dynamit Nobel, Burbach-Wurgendorf.

Dengel presented a paper entitled "Entropy and the Homogeneity of Solid Mixtures" at the ICT conference. ICT, an Institute of the Fraunhofer Gesellschaft, is concerned with the chemical technology of high explosives, propellants, and pyrotechnics. It organizes annual conferences regarding the technology of energetic materials. The theme of this 18th conference was the manufacturing and processing of energetic materials. The conference was attended by about 440 people from 25 countries. The presentations are published in the conference proceedings, which were available at the meeting.

#### Electronics

*Invited:* Mr. R. L. Hughes and Dr. W. E. Carlos, both of Code 6816, *Electronic Technology Division, Naval Research Laboratory, Washington, DC 20375-5000.*

Hughes and Carlos attended the International Conference on the Physics and Technology of Amorphous SiO<sub>2</sub> held from 29 June-3 July 1987 at Les Arcs, France. The conference was attended by 92 scientists from 15 countries with the majority from Western Europe and smaller delegations from Eastern Europe, the US, Japan, and Israel.

The diverse interests of the participants are shown by the fact that the topics ranged from crystallography to the effects of irradiation on semiconductor devices. About 50 invited and contributed papers were presented along with about 25 posters. Session titles were as follows: Structures, Defects, Si-SiO<sub>2</sub> Interface, Oxidation and Diffusion, Laser-Induced Effects, Transport and Trapping, Breakdown, Radiation Effects and Reliability, and Buried Dielectric Layers.

The conference proceedings should be published in early 1988. Details concerning the proceedings or other more detailed information on this conference should be available from any of the conference co-chairs: Professor Jörg Arndt of the University of Tübingen, West Germany; Dr. Roderick Devine of CNET (France's National Telecommunications Research Center), Meylan, France; or Dr. Akos Revesz of NRL, Washington.

#### Oceanography

*Invited:* Kenneth M. Ferer, *Project Manager, Ocean Programs Management Office, Naval Ocean Research and Development Activity, NSTL Station, Mississippi 38619.*

Mr. Ferer attended the 19th International Liège Colloquium on Ocean Hydrodynamics held in May 1987 at the University of Liège at Sart-Tilman, Belgium. The meeting was essentially concerned with discussion of small-scale turbulence and mixing in the ocean. Papers were given by representatives from Australia, Belgium, Canada, West Germany, Norway, Sweden, the UK, USSR, and the US (which provided the majority of papers).

As pointed out by the speakers reviewing progress during the 8 years since the last conference, that progress has been relatively slow due to lack of observational measurements. What *in situ* measurements have been achieved took place within the past 2 years and have come mainly because of the US Navy's funding of instrumentation and *in situ* experiments. Both ONR's and the Oceanographer of the Navy's instrumentation support have contributed significantly.

Papers included discussion of deliberate chemical tracers and their continued use to determine thermocline ventilation and diapycnal mixing rates; advances in upper ocean modeling (which have emphasized the importance and relationship of diapycnal and isopycnal modeling--with significant improvement in upper ocean presentation formats); and C-SALT and its multiorganization effort.

A new development was the description of small-scale vertical motions. The potential energy field was broken down into the gravity motion of vertical internal waves and the vortical motion of horizontal vortices. It was suggested that while

vortical motions have only 10 percent of the energy within the IW field it contains the greatest portion of the shear motion.

A "Glossary of Terms for Small-Scale Turbulence and Mixing in the Ocean," produced by the organizing committee, was distributed. There appeared to be unanimous agreement that small-scale turbulence is defined as a nearly isotropic eddy-like state of fluid motion where the inertial forces of the eddies are larger than the buoyancy forces and viscous forces that arise to damp them out.

Proceedings of this colloquium were scheduled for publishing and distribution in late 1987.

#### Physics

*Traveler:* Dr. A. W. Ali, Plasma Physics Division, Code 4700, Naval Research Laboratory, Washington, DC 20375-5000.

Dr. Ali attended the Eighteenth International Conference on Phenomena in Ionized Gases (ICPIG), held in Swansea, UK, in July 1987. There were 449 participants from 45 countries and all populated continents except South America. Eastern European countries were well represented with some 74 conferees, of whom 46 were from the USSR.

Topics considered at this conference were: kinetics, thermodynamics, and transport phenomena; waves and instabilities; laser and particle beam interaction with plasmas; plasmas in space; plasma chemistry; non-ideal plasmas; elementary processes; electrode and surface effects; ionization growth and breakdown; RF, microwave, and laser-induced discharges; coronas; sparks and high-pressure glows; arcs; plasma spectroscopy; diagnostics; and theoretical modeling.

There were 11 general invited lectures, the majority being reviews and updates of the current status of the fields. Few of these were topics which can be considered as new or in developing fields such as dynamical chaos in plasma or discharges in extremely high values of  $E/N$ . There were 26 topical invited lectures, which signifies the diverse interests within the ICPIG; these span basic and applied physics and extend to some engineering aspects as well.

The particular papers Ali reviews include: experimental results in argon for very high value of  $E/N$  in low-pressure gas; the ionization kinetics in shock-treated rare gases; the current status of the laser-triggered switches (LTS); and line broadening mechanisms, with emphasis on Stark broadening.

*Traveler:* Dr. Fereydoon Family, Department of Physics, Emory University, Atlanta, Georgia 30322.

Dr. Family attended the meeting at Cambridge University, UK, "Faraday Discussion 83, Brownian Motion," held in April 1987.

Dr. Family prefaces his report by stating that the essential mechanism of Brownian motion is the continuous "buffeting" of the suspended particle by the molecular components of the fluid due to their thermal motion. At each collision the suspended particle suffers some displacement, and its subsequent motion is a random walk. He continues, saying that in the past decade there has been an explosive growth in the theory and applications of Brownian processes and random walk models. Brownian motion and random walk models have appeared in diverse subject areas, in biology, chemistry, engineering and physics, to mention just a few.

This meeting was organized by the UK's Royal Society of Chemistry to bring together a spectrum of scientists to discuss new developments in the experimental and theoretical studies of Brownian motion of colloidal particles and macromolecules with particular emphasis on the dynamics of aggregate formation and breakdown, computer simulation and many-body hydrodynamic interactions.

The first group of papers dealt mainly with both theoretical and experimental studies of Brownian motion of tracer particles. Understanding the dynamics of tracer particles immersed in a dispersion of other diffusing particles is a problem of considerable interest from both practical and theoretical points of view. Since dynamic light scattering has become one of the most powerful methods for the study of various aspects of Brownian motion, there were several papers on use of light scattering techniques.

The second group of papers dealt primarily with colloidal systems, and in this group were several presentations that reflected the interest generated during the past few years by the discovery that the patterns produced by diffusion-limited aggregation processes and colloidal aggregates have structures that can be described by fractal geometry. (Dr. Family's own presentation of his work, done in collaboration with George Hentschell of Dowell-Schlumberger, was on the analytical approach for determining the fractal structure of diffusion-limited clusters in the presence of anisotropy.)

The third group of papers dealt with various topics related to Brownian dynamics, and the fourth group dealt with colloidal suspensions.

#### REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Information on each of the reports listed below was furnished by the activity identified by the abbreviations for that office. Requests for copies of or information about the document should be addressed to the appropriate office:

USARDSG--US Army Research Development and Standardization  
Group, Box 15/65, FPO New York, 09510-1500  
EOARD--European Office of Aerospace Research and Development,  
Box 14, FPO, New York 09510

#### Chemistry

*Rigid-Rod Polymer and Selective Fluoridization Research at Tel Aviv University*, by MAJ Scott Shackelford, EOARD. (17 pp) [Report No. EOARD-LR-87-65.]

Studies using a fused bicyclic ring system monomer family termed "bimanes" show that bimanes have promise as highly thermally stable materials which could also solve the rigid-rod fiber problem with compressive strength. Professor Edward M. Kozower is investigating bimane isomeric monomers and bis-bimane derivatives (dec. 300°C) for use in ordered polymeric fiber applications, and has synthesized diacetylene-terminated bimane derivatives for subsequent polymerization. Professor Shlomo Rozen has successfully tamed highly reactive F<sub>2</sub> gas by using it to produce mild selective organic fluorinating reagents *in-situ*. This approach has been successful at converting carbonyl moieties to the gem - CF<sub>2</sub> group, in substituting tertiary hydrogen atoms with fluorine, and in synthesizing vicinal to mixed dihaloalkanes and vic fluoromethoxyalkanes.

*Fundamental Studies on Organic Synthetic Metal Conduction at Ben-Gurion University*, by MAJ Scott Shackelford, EOARD. (15 pp) [Report No. EOARD-LR-87-66.]

An interdisciplinary research group headed by four professors in synthetic organic chemistry, crystallography, electrochemistry and theoretical chemistry has been assembled at the Department of Chemistry, Ben Gurion University of the Negev, at Beer-Sheva, Israel. This group has identified five fundamental factors at the molecular and microstructural level which affect the type and degree of conductivity possessed by organic materials. While past research in this area has proceeded very empirically, this group is systematically investigating the influence of these five factors to identify how at the molecular/microstructural level, these conductive properties may be selectively varied and designed into an organic material. This fundamental information might also have applicability to optical transmission considerations. Studies in conformational polymorphism and molecular structure/property relationships are also being pursued.

*Hot Corrosion in Gas Turbines: A New, Unique and Informative Technique is EASE*, report under contract AFOSR 84-0338 by Dr. Trevor R. Griffiths, Department of Inorganic and Structural Chemistry, The University of Leeds. (77 pp) [Report No. EOARD-TR-87-09.]

The hot corrosion of advanced turbine materials used in aerospace applications may now be studied successfully with EASE (Electronic Absorption Spectroscopy Experiments). This technique permits the continuous monitoring of the dissolution of corrosion products into molten sulphate deposits under conditions which effectively replicate operating conditions. The EASE technique was originally developed for studying hot corrosion on superheater tubes, and this preliminary study has developed and extended it to turbine materials, where the effects of thermal cycling and chloride addition can be followed. The report details the spectroscopic studies made and how rates are obtained from spectra; the design and testing of thermal gradient furnaces; and some crucible and spectroscopic studies of IN 738 in sulphate + chloride melts. A recently marketed American fiber optic spectrophotometer could be modified to enhance EASE studies and make *in situ* studies of operating turbines.

Life Sciences

*Neuroscience of Vision*, by MAJ Jim McDougal, EOARD. (3 pp) [Report No. EOARD-LR-87-69.]

The Laboratory of Physiology at the University of Oxford is internationally recognized for its investigations in the field of neuroscience. Professor Colin Blake-more has groups involved in various aspects of visual perception in several laboratory species. One group is involved in electrophysiology (*in vitro* and *in vivo*) and anatomical studies with horseradish peroxidase in the visual cortex of rats and cats. They are combining these studies into a computer model which will simulate electrical activity in the visual cortex. Another group is involved in studying neurophysiology in old world primates. They have recorded from the foveal region of the striate cortex and determined spatial contrast sensitivity function and will move on to investigate chromatic sensitivity.

Materials

*Electron Microscopy Studies of Carbon and Ceramics*, by LTC Jim Hansen, EOARD. (4 pp) [Report No. EOARD-LR-87-64.]

Madam Oberlain at the University of Pau, France, leads a group performing electron microscopy on constituents of composites. Materials studied include carbon fibers, silicon carbide fibers, and graphite. A special technique developed for these studies is dark field imaging in transmission electron microscopy.

*Sol-Gel Research at Two French Universities*, by LTC Jim Hansen, EOARD. (8 pp) [Report No. EOARD-LR-87-67.]

At the University of Paris, Professor Livage directs a research group with excellent capabilities in the chemistry of sol-gel processes and in spectroscopic analysis. A 500°C capability in their nuclear magnetic resonance spectrometer is to be applied to sol-gels. At the University of Montpellier, Professor Zarzycki heads a materials science effort, utilizing ultrasonics to form extremely dense sonogels, to overcome shrinkage and microcracking problems. Other strengths include fractal characterization of sol-gels.

*Aluminalon*, by LTC Jim Hansen, EOARD. (2 pp) [Report No. EOARD-LR-87-68.]

Aluminalon, a new ceramic material, has been developed by researchers at Ecole Nationale Supérieure des Mines in Saint-Etienne, France. Aluminalon is a dispersion of gamma aluminum oxynitride in an alumina matrix, with no vitreous grain boundary phase. Tribological properties are most notable, especially following oxidation treatment.

Mechanics

*True 3-D Viewing of CFI or CAD Results*, by LTC Bob Winn. (1 p) [Report No. EOARD-LR-87-76.]

Professor Jim Swithenbank at the University of Sheffield has developed a true three-dimensional viewing system for microcomputer graphics displays. It was developed for use in analyzing complex fluid problems but has applications to computer-aided design as well. This system costs only about \$3,000 beyond the cost of the microcomputer.

*Report on the 17th International Symposium on Shock Tubes and Pipes*, by LTC Bob Winn. (7 pp) [Report No. EOARD-LR-87-77.]

This conference was held in Aachen, West Germany, in late July 1987. This report consists of a list of the specific topic areas covered in the symposium and has a list of paper titles and authors attached.

*ICFD Report*, by LTC Bob Winn, EOARD. (44 pp) [Report No. EOARD-LR-87-78.]

Professor Bill Morton is heading up the Institute for Computational Fluid Dynamics, a combined effort of the Universities of Oxford and Reading. Work in this institute is on the leading edge of Euler code development particularly in the area of "shock fitting." This report consists of a brief outline of their work and a copy of the institute's annual report.

Physics

*Laser Technology Research Institute--Vienna*, by Dr. Stacey Lazdinis, EOARD. (2 pp) [Report No. EOARD-LR-87-43.]

The Institut für Nachrichtentechnik of the Technische Universität in Vienna is establishing a laser technology research institute. Interesting work in higher power CO<sub>2</sub> and TEA lasers is also being done.

*Laser Techniques in Atomic and Molecular Physics*, by Dr. Stacey Lazdinis, EOARD. (4 pp) [Report No. EOARD-LR-87-44.]

The Laboratoire de Spectrométrie Physique of the University at Grenoble, France is applying sophisticated laser techniques to extend the scope of their research in atomic and molecular physics.

#### TECHNOLOGY ROUNDUP--ITALY

The items below were received from the American Embassy in Rome. For further information, contact Dr. Gerald Whitman, Office of the Science Counselor, American Embassy, Rome, APO New York 09794-0007.

New Robot Employs Artificial Vision. Selenia Elzag has developed a robot able to visually recognize spare parts on an industry assembly line and to transfer them to the area where they will be employed. Testing of the robot, known as the "Faber C 5000 DEA" will be complete by the end of the year. In addition, Selenia Elzag is active in the automated postal system area and is readying a system, "Emma 2," capable of reading documents automatically. The system is presently being studied by the US Internal Revenue Service.

Montedison to Simulate Origins of Disease. Montedison, the Italian chemical giant, has announced a project to build advanced analytical devices capable of investigating through simulation the biological origins of cellular anomalies and diseases. The program will be carried out by ME.S.A., an automation systems company of the Montedison Group, ME.S.A. is expected to spend 5 billion lire (about \$3.8 million) on the program over the first 3 years.

Bruno Coppi to Head New Fusion Research in Turin. Prominent Italian physicist Bruno Coppi has accepted the offer of the Piedmont Regional Administration to head a new fusion research program at Turin Polytechnic University. Coppi's research will be supported by an association comprised of the regional administration, the university, and several Turin industries.

New Fusion Project in Padua. The National Research Council (CNR) Institute of ionized gases and the CNR Padua Research Group on fusion announced a new experiment on magnetic field nuclear fusion. Scheduled to start in Padua in 1989, the experiment is expected to cost 70 billion lire (about \$52 million) and will require the construction of a plasma ring (4-meter external diameter) with a 2-million-ampere electric power capacity. The project is financed by CNR, the University of Padua, the Italian Agency for Nuclear and Renewable Energy (ENEA), and by EEC.

Olivetti to Establish Informatics Research Centers. The Italian Interministerial Committee for Industrial Programming awarded a contract to Olivetti worth 700 billion lire (about \$55 million) through 1990 to establish high-qualification research centers on informatics to encourage research and productivity in the south of Italy. Olivetti will establish, in cooperation with local universities and institutions, several research centers for new RISC (reduced instruction set computer) architectures for the realization of innovative microcomputers; office automation; development of hardware and software modules for the OSI (open system interconnection) European standards of communication; artificial intelligence systems design; and development of memory cards based on laser technologies.

Artificial Intelligence Research in Italy. Italy at present has 135 research and operational groups working in artificial intelligence (AI), according to a report released at the International Conference on Artificial Intelligence in Milan last August. The report states that about 1000 persons are currently involved in AI research, with an expenditure of about 56 billion lire (about \$41 million) in 1986--about 11 percent of the European total. The Italian market for AI, estimated at around 7 billion lire in 1986, is expected to reach about 30 billion in 1987 and 120 billion per year by 1990. Industrial automation alone allows for 60 percent of Italian expert systems activity. At present, Italian industry is operating two large AI expert systems. The first, "Arianna," is employed for production planning in the Pirelli Tire and Rubber Factory in Tivoli. The second, called "Prop," monitors the water cycle in hydroelectric power plants of the Italian National Electric Agency (ENEL). Fiat, Telettra, ENI, Italsider, Montefiber, and the Italian state railway all plan to have expert systems on line within the next few months.

Consortium Formed for Advanced Microelectronics Laboratory in Cantania. The University of Cantania in Sicily with the companies SGS Microelectronica and Innovazione Silicon Technology, both of the IRI-STET group, have formed a consortium for the establishment of an advanced microelectronic research laboratory at the university. The laboratory will explore areas of intelligent and non-intelligent power microelectronics as well as programmable and non programmable logical circuits. The government is financing the laboratory through its plan for the development of the south. About 157 billion lire (\$120 million) have been allotted to the laboratory for the 3-year period 1987/89.

Progress in Ceramics Research. The director of CNR's Institute for Electronic Theory and Structures noted the growing capabilities of Italian industry to produce technologically advanced ceramic material. Industries such as SAMIM and Eniricerche of the ENI Group, CSM (Centro Ricerche Materiali) of Ansaldo, and Montedison are initiating significant research in ceramic materials. Moreover, one of the four sub-projects of the new CNR-finalized project on "special materials for advanced technologies" is dedicated to neoceramic materials. The project covers process technologies, structural ceramics, electroceramics, and glasses; the estimated cost for five years is 28 billion lire (about \$21 million). It will involve 50 research groups with industry participation at about 40 percent.

Development of Advanced Computational Techniques. The Italian company Rambaudi of Turin signed a contract with McDonnell Douglas for the joint development of new advanced computational techniques for the design of complex mechanical structures. A test facility will be established in the Rambaudi facilities in Turin. Rambaudi employs 420 individuals and has a business turnover of 60 billion lire (about \$47 million).

#### SCIENCE NEWSBRIEFS FOR DECEMBER

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during December. *Science Newsbrief* provides concise accounts of scientific research developments, meeting announcements, and science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

##### Number

- 5-12 Meetings in UK Organized by Institute of Physics by Louis Cartz.
- 5-13 Shortest Laser Pulse Record in the UK by Paul Roman.

#### DECEMBER MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during December. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the *Bulletins*, by number, from ONR, London.

##### Number

- 50-87 Skyshark Italian Standoff Weapon Dispenser
- 51-87 Copper-on-Alumina Microelectronic Packaging
- 52-87 Third Quarterly Index 1987

## SUBJECT INDEX OF 1987 ONRL PUBLICATIONS

Volume 41 ESN and 1987 ESNIB

The articles are listed chronologically under the subject heading, with title, author, and issue page numbers. All ESN entries are for volume 41 (1987). Thus, for ESN references, 6:211 indicates issue 6, page 211 of volume 41. For ESNIB, 87-01:16 indicates 1987, issue 1, page 16.

ACOUSTICS

- |  |       |                 |
|--|-------|-----------------|
| Conference on Fluctuation Phenomena in Underwater Acoustics--Four Invited Papers | 7:349 | Hassan B. Ali   |
| Conference on Fluctuation Phenomena in Underwater Acoustics--Contributed Papers  | 7:351 | David H. Berman |

BEHAVIORAL SCIENCES

- |   |         |                  |
|---|---------|------------------|
| Research in Personality at the Rijksuniversiteit Groningen  | 3:115   | William D. Crano |
| Researchers at Trondheim University Relate Dyslexia and Hormonal Deficiency   | 3:118   | William D. Crano |
| Psychological and Behavioral Reactions to Catastrophes Are Subjects of Report on a NATO Symposium   | 4:175   | William D. Crano |
| Capabilities of the Young are Discussed at the Second European Conference on Developmental Psychology   | 4:178   | William D. Crano |
| Norway's Center for Disaster Psychiatry: A Unique Institution for the Study and Treatment of Victims of Catastrophe                             | 5:227   | William D. Crano |
| European Perspectives on the Psychology of Work and Unemployment: I. The Italian Reality--Methodological and Substantive Contributions          | 6:287   | William D. Crano |
| European Perspectives on the Psychology of Work and Unemployment: II. The Belgian Problem   | 6:291   | William D. Crano |
| Basic Research and Applied Psychology in Eastern Switzerland  | 7:352   | William D. Crano |
| Computer-Assisted Personality Assessment Device Now Available   | 8:450   | William D. Crano |
| Aggression the Focus of a Recent Conference in Spain  | 9:467   | William D. Crano |
| Report of the NSIA International Conference on Military Personnel and Training, with Special Emphasis on Computer Adaptive Testing and Training | 10:539  | William D. Crano |
| Research on Social Comparison, Range Seeking, and Their Relationship  | 87-01:1 | William D. Crano |
| Research on Internal and External Memory Systems Conducted at the Free University of Berlin   | 87-02:1 | William D. Crano |

BIOLOGICAL SCIENCES

- |   |       |                           |
|---|-------|---------------------------|
| Neurobiology Workshop: "The Making of the Nervous System," Wye College, University of London, Kent, July 1986 | 1:1   | Claire E. Zomzely-Neurath |
| Neurobiology: Sixth Meeting of the European Society for Neurochemistry  | 1:6   | Claire E. Zomzely-Neurath |
| Neurobiochemistry: 17th FEBS Meeting  | 2:57  | Claire E. Zomzely-Neurath |
| Gene Technology: 17th FEBS Meeting  | 2:60  | Claire E. Zomzely-Neurath |
| Biotechnology: 17th FEBS Meeting  | 2:63  | Claire E. Zomzely-Neurath |
| EUREKA Proposals in Biotechnology   | 2:104 | Claire E. Zomzely-Neurath |
| Biotechnology in East Germany   | 3:121 | Claire E. Zomzely-Neurath |

Regulatory Peptides in the Brain and in the Gastrointestinal Tract is Topic of Workshop	3:124	Claire E. Zomzely-Neurath
Biotechnical '86: Second International Congress and Exhibition for Biotechnology	3:151	Claire E. Zomzely-Neurath
Third European Seminar and Exhibition on Computer-Aided Molecular Design	4:181	Claire E. Zomzely-Neurath
Molecular Biology: Eukaryotic Chromosome Replication	5:230	Claire E. Zomzely-Neurath
Molecular Biology: Conference on Genetic Engineering Techniques	5:235	Claire E. Zomzely-Neurath
Bioelectrochemical Symposium: Formations and Reactions of Peroxides in Biological Systems	5:239	Claire E. Zomzely-Neurath
Biotechnology: Conference on Large-Scale Production of Monoclonal Antibodies	5:244	Claire E. Zomzely-Neurath
Biotechnology: Product Manufacture by Immobilized Metabolizing Cells	6:296	Claire E. Zomzely-Neurath
Biotechnology Research at the Technical University of Denmark	6:299	Claire E. Zomzely-Neurath
Neurobiology Research at the University of Copenhagen	6:302	Claire E. Zomzely-Neurath
Biotechnology: "Bioexchange '87," A Conference on UK Research in Biotransformations	7:358	Claire E. Zomzely-Neurath
Life Science Research at Aarhus University, Denmark	7:364	Claire E. Zomzely-Neurath
Biotech '87 Focuses on Biosensors and Environmental Biotechnology	8:415	Claire E. Zomzely-Neurath
Update on Biotechnology Research in West Germany	8:451	Claire E. Zomzely-Neurath
Biotechnology Conference: Protein Engineering '87, University of Oxford	9:474	Claire E. Zomzely-Neurath
Second Messengers Signalling Future Areas for Drug Research	9:479	Claire E. Zomzely-Neurath
The Second International Symposium on Quantitative Luminescence Spectrometry in the Biomedical Sciences	10:544	Claire E. Zomzely-Neurath
Water and Ions in Biological Systems-- The Fourth International Conference	87-01:6	Claire E. Zomzely-Neurath
17th Annual Meeting of the Scandinavian Society for Immunology	87-02:7	Claire E. Zomzely-Neurath
Biotechnology at Warren Spring Laboratory, Stevenage, UK	87-02:13	Claire E. Zomzely-Neurath
Report of Future Sensor Needs of UK Biotechnology-Based Industries is now Available	87-02:57	C.J. Fox

CHEMISTRY

International Symposium on High-Temperature Corrosion	1:10	Robert L. Jones
Thermosalt: A Thermodynamic Data Bank of Molten Salt Mixtures	4:207	M. Gaune-Escard
Fungus Provides Economical "Filter" for Industrial Effluents	5:269	C.J. Fox
XIII Sandbjerg Meeting on Organic Electrochemistry	87-01:11	M. Irene Montenegro

COMPUTER SCIENCE

The EUREKA Program	1:12	J.F. Blackburn
Control Theory Groups at Vienna and GRAS	1:49	Daniel J. Collins
Pyramidal and Concurrent Computer Architecture at Erlangen University	2:66	J.F. Blackburn
Suprenum: The German Supercomputer	2:71	J.F. Blackburn
Sieman and Philips Work in Submicron Technology for Integrated Circuits	3:153	J.F. Blackburn



Computer Scientists Gather in Dublin at the 10th World Computer Congress	4:186	Paul Roman
Computer Science in the UK--A Report on a Visit to Britain	4:205	J. Goguen
Control Theory at the University of Stuttgart	4:277	Daniel J. Collins
Distributed Real-Time Computing Systems R&D at INRIA	6:307	J.F. Blackburn
Robot Manipulators with a High Number of Degrees of Freedom	6:309	J.F. Blackburn
Network Communications Facilities and Communications Research at INRIA-- An Overview	7:367	J.F. Blackburn
A New Approach for the Recognition and Positioning of Two-Dimensional Objects	7:369	J.F. Blackburn
International Symposium on Simulation of Control Systems	7:372	Daniel J. Collins
The Birth and Growth of CLIP--The Cellular Logic Image Processor	8:422	J.F. Blackburn
A European Center for Artificial Intelligence Research and Developments	8:456	Paul Roman
Further Developments in Image Processing at University College, London	9:483	J.F. Blackburn
Audible Speech Recognizer--A British Technology Group Project	9:486	J.F. Blackburn
25th IEEE Conference on Decision and Control	9:488	Daniel J. Collins
Artificial Intelligence at Lisbon's Universidade Nova	9:492	Paul Roman
Basic Research in Artificial Intel- ligence at Berlin's Technical University	9:520	Paul Roman
Control Theory at the National Technical University in Greece	10:549	Daniel J. Collins
Control Research at Northern Universities in Italy	87-01:13	Daniel J. Collins
A Review of Nonlinear and Robotic Control Theory in Southern Italy	87-01:16	Daniel J. Collins
"FRIL" is Commercially Available	87-01:68	Paul Roman

ELECTRONICS

Microelectronics at the University of Edinburgh	4:192	Robert W. Vest
Research in Superconductivity at Cambridge University, UK	10:551	J.F. Blackburn
Optoelectronics at University College, London	87-01:19	J.F. Blackburn

ENVIRONMENTAL SCIENCES

Meeting on Atmospheric Studies by Optical Methods	2:75	Jerome Williams
Studies of the Middle Atmosphere-- A Royal Society Meeting	4:197	Jerome Williams

MATERIAL SCIENCES

Fifth Europhysical Topical Conference, Lattice Defects in Ionic Crystals	1:45	David L. Griscom
Highlights from the 8th International Conference on Solid-State Dosimetry	1:46	R.J. Abbundi
Research at Plessey (Caswell) on Materials for Pyroelectric Detectors	2:78	Robert W. Vest
Tribology Research at Laboratoire de Technologie des Surfaces	2:82	Irwin Singer
NATO Workshop on the Design, Activation, and Transformation of Organometallics into Common and Exotic Materials	3:129	Robert W. Vest

Some Observations on Research in Poland on Materials for Thick-Film Hybrid Microelectronics	3:133	Robert W. Vest
The 8th International Conference on Crystal Growth	3:154	Louis Cartz
A Passive Preprogramed Memory Using Thick- Film Technology	5:269	Robert W. Vest
Crystal Growth Under Microgravity Conditions	5:244	Louis Cartz
The French Society of Metallurgy Metal Surface Treatment, Studies at Centre de Recherches d'Unieux in France	5:253	Louis Cartz
High-Temperature Alloys for Gas Turbines and Other Applications	5:271	Louis Cartz
	6:312	Dasara V. Rathnamma, S.R.J. Saunders, and T.B. Gibbons
Computer Aided Engineering for Surface Mount Technology in the UK	6:314	Robert W. Vest
Surface Analysis Laboratory, University of Surrey, UK	6:336	Louis Cartz
Materials Analysis for Electronic Devices: A UK Meeting	7:377	Louis Cartz
Nondestructive Testing Center, Harwell, UK	7:402	Louis Cartz
Electronic Ceramics Research at Three Israeli Universities	8:425	Robert W. Vest
Research on Advanced Ceramics and Gas Sensors at Harwell	8:427	Robert W. Vest
An Exciting Meeting of the Dielectrics Society	9:494	Robert W. Vest
Research on Thick Film Hybrids in Italy (Telettra, Marelli, and the University of Modena)	9:496	Robert W. Vest
Research on Fuel Cells and MOCVD at Imperial College	10:553	Robert W. Vest
Composite Materials Conference in France	10:555	Louis Cartz
Some Observations on Hybrid Micro- electronics in Yugoslavia	87-01:22	Robert W. Vest
Engineering Ceramics: A One-Day Meeting in the UK	87-01:26	Louis Cartz
Materials Meeting in London, UK	87-01:29	Louis Cartz
Stress Relieving After Welding: Eastern European Approaches	87-01:33	Kenneth D. Challenger
Sixth European Microelectronics Conference (EMC/87)	87-02:17	Robert W. Vest
Creep and Fracture of Engineering Materials and Structures--Third International Conference	87-02:19	John P. Gudas
Sialon Ceramics Research at the University of Newcastle-Upon-Tyne	87-02:23	Louis Cartz
Materials Research In Göteborg, Sweden	87-02:57	Louis Cartz
Hydraulics and Fluid Mechanics Research at Ecole Polytechnique Federal de Lausanne	87-02:59	Louis Cartz
<u>Mathematics</u>		
Artificial Intelligence and Related Research at Salerno	87-02:26	Paul Roman
<u>Mechanics</u>		
Aerodynamics and Engineering at ONERA	1:15	Eugene F. Brown
Vortex Flow Symposium	1:20	Eugene F. Brown and E.M. Murman
European Meeting of Turbulent Drag Reduction	2:87	Eugene F. Brown

Fluid Mechanics at the University of Glasgow	4:201	Eugene F. Brown
First International Symposium on Domain Decomposition Methods	5:256	Eugene F. Brown
Combustion and Energy Studies at the University of Leeds	5:273	Eugene F. Brown
Research and Development Activities in Fluid Mechanics at Rolls-Royce	5:275	Eugene F. Brown
Fluid Measurement Capability at the Institute for Hydraulic Engineering	5:278	Daniel J. Collins
Fluid Mechanics Research at Ecole Nationale Supérieure d'Hydraulique	6:318	Eugene F. Brown
Fluid Mechanics Research at the Ruhr-Universität Bochum	6:321	Eugene F. Brown
Fluid Mechanics Research at the Technical University of Vienna	6:329	Eugene F. Brown
Institute for Numerical Methods and Engineering at the University of Wales, Swansea	6:331	Eugene F. Brown
Harwell Laboratory Participating in European Combustion Initiative	6:332	Eugene F. Brown
Fluid Mechanics Research at Two Edinburgh Universities	6:333	Daniel J. Collins
Fluid Mechanics Research at The Technical University of Berlin	7:380	Eugene F. Brown
Turbulence, Drag Reduction, and Acoustics Research at the Max Planck Institute and DFVLR-Berlin	7:381	Eugene F. Brown
Fluid Mechanics at the National Technical University of Athens	7:385	Daniel J. Collins
AGARD's 68th Propulsion and Energetics Meeting	7:388	Daniel J. Collins
Fluid Dynamics and Control Theory Research in Denmark	7:390	Daniel J. Collins
Institute of Design Aerodynamics at DFVLR Braunschweig	7:405	Eugene F. Brown
Aerodynamics of Hypersonic Lifting Vehicles--AGARD	8:430	Eugene F. Brown
EUROMECH 220: Mixing and Chemical Reactions in Turbulent Flows	8:437	Eugene F. Brown
Aerodynamics and Hydrodynamics Research in Rome	9:501	Eugene F. Brown
Italian Contributions to the Lambda Formulation	9:504	Eugene F. Brown
Fluid Mechanics Section, Imperial College, London	9:508	Eugene F. Brown
Unsteady Flows and Turbulence at IMFL	9:510	Daniel J. Collins
Fluid Mechanics--An Evolutionary Approach	9:522	Eugene F. Brown
Computational Fluid Dynamics at the Politechnic Institute of Milan	9:525	Eugene F. Brown
Prospectives in Turbulence Studies--An International Symposium	10:558	Eugene F. Brown
Von Karman Institute for Fluid Dynamics	10:563	Daniel J. Collins
Greece's Air Force Technology Research Center	10:592	Daniel J. Collins
The UK's Computational Mechanics Institute--Software, Teaching, and Publication	10:594	Daniel J. Collins
NATO Workshop on Mathematical Modeling in Combustion	87-01:36	Eugene F. Brown
Shock/Boundary-Layer Interaction, Vortex Flow, and Process Automation Research At RWTH Aachen	87-01:40	Daniel J. Collins
Fiat Research Center at Turin	87-01:60	Daniel J. Collins
Joint Meeting of the French and Italian Combustion Societies	87-02:28	Eugene F. Brown
US-France Workshop on Turbulent Reactive Flows	87-02:35	Eugene F. Brown

---

Fluid Mechanics Research at the University of Naples	87-02:42	Eugene F. Brown
Fluid Mechanics and Combustion Research at the Polytechnic University of Madrid and the University of Zaragoza	87-02:45	Eugene F. Brown
<u>OCEAN SCIENCES</u>		
European Geophysical Meeting--August 1986	2:92	Jerome Williams
Meeting of the International Commission for the Scientific Exploration of the Mediterranean Sea	3:139	Jerome Williams
UK Oceanography '86	3:165	Jerome Williams
Oceanic and Atmospheric Variability	3:166	Jerome Williams
Hydrographic Society Holds Its 5th Biennial International Symposium	4:219	Jerome Williams
Marine Science at Plymouth, UK	6:337	Jerome Williams
The Institute of Oceanographic Sciences, Bidston, UK	6:340	Jerome Williams
The Remote Sensing Group at the Chalmers University of Technology, Gothenburg, Sweden	6:341	Jerome Williams
Yugoslavian Marine Science Institutions	7:395	Jerome Williams
Oceanographic Research in Norway	8:439	Jerome Williams
Overview of Marine Science Activity at Israeli Facilities	8:442	Jerome Williams
Community Programs in Marine Science	8:459	Jerome Williams
An Informal Meeting of British Ocean Modelers	9:512	Jerome Williams
Tidal Measurements and Instrumentation--A Seminar by the UK's Hydrographic Society	9:515	Jerome Williams
Workshop to Reconcile Research Differences on Radar Imagery of Ocean Surface Features	9:526	Gaspar R. Valenzuela
European Geophysical Society--XII General Assembly	9:529	J. Simpson and George W. Heburn
The Marginal Ice Zone Experiment: MIZEX-87	10:567	Donald Johnson and Jeffrey Hawkins
The Oceanography Session of the European Remote Sensing Meeting	10:570	Jerome Williams
Research in Air-Sea Interface at IMST, Luminy, France	10:595	Jerome Williams
Oceanography at a Small Laboratory in Toulon, France	10:596	Jerome Williams
Marine Science at the Netherland's Hydraulic Laboratory	87-01:43	Jerome Williams
Oceanography on the French Riviera--Laboratoire de Physique et Chimie Marines	87-01:45	Jerome Williams
Tracers in the Ocean--A Small International Meeting	87-01:47	Jerome Williams
Southampton University to Create Underwater Acoustics Chair	87-01:65	Jerome Williams
Remote Sensing Programs Sponsored by the French Ministry of Research	87-01:65	Jerome Williams
COST-43: Seminar on Operational Ocean Station Networks	87-02:48	Jerome Williams
Air-Sea Interaction Meeting of the UK's Royal Meteorological Society	87-02:51	Jerome Williams
Oceanography: Institut Francais De Recherche Pour L'Exploitation Des Mers (IFREMER)	87-02:61	Jerome Williams
<u>PHYSICS</u>		
Scanning Tunneling Microscopy: STM '86	1:25	C.F. Quate
A Revolution in the Making		

Scanning Tunneling Microscopy: STM '86 Highlights of Research from Six European Laboratories	1:31	Azzam N. Mansour
An All-European Conference on Atomic Spectroscopy	1:33	Paul Roman
An International Meeting on Infrared Technology	1:38	Paul Roman
Gas Laser Research at Twente	2:96	Paul Roman
Neuperlach Revisited: New Trends in the Optoelectronic Research Division of Siemens AG	2:99	Paul Roman
Novel Imaging Multichannel Laser Spectroscopy System Developed at DFVLR	2:110	Paul Roman
Infrared Signature Studies at Oberpfaffenhofen	2:111	Paul Roman
A Mass Meeting of Semiconductor Scientists Held in Stockholm	3:143	Paul Roman
Microstructure Experts Had a Fine Working Conference at Göteborg	3:148	Paul Roman
An ONRL-Sponsored Workshop on Optical Interconnects	3:167	Paul Roman
Synthetic Diamonds as Radiation Detectors	4:209	E.D. Hagee
New Laser Media: An ONRL-Sponsored Conference-Session in Jerusalem	4:210	Paul Roman
ONR Branch Office London Sponsors a Session on Interfacial Phenomena in Microelectronics	5:259	Paul Roman
Optical Communication Conference Draws Crowds to Barcelona	5:261	Paul Roman
International Conference on Anomalous Rare Earths and Actinides	5:280	Alan S. Edelstein
ONRL-Sponsored Workshop on Fractals and Chaos	6:324	Paul Roman
Optoelectronics Research at Dublin's Trinity College	6:327	Paul Roman
Plessey's Allen Clark Research Center	6:342	Paul Roman
A Large Gathering of Solid-State Physicists	7:398	Paul Roman
A Small European Working-Conference on Amorphous Semiconductors	7:400	Paul Roman
Scanning Tunneling Microscopy in Madrid	8:446	Paul Roman
Ultrahigh-Resolution Laser Spectroscopy Serves Basic Physics in Munich	8:448	Paul Roman
Gallium Arsenide Research at Stuttgart's Max Planck Institute	8:456	Paul Roman
Pioneering Semiconductor Device Research at Stuttgart University's Physics Department	8:457	Paul Roman
Laser Research at the German Aerospace Research Establishment Laboratories in Stuttgart	9:517	Paul Roman
Siemens Ready to Supply High-Power Semiconductor Laser Arrays	9:528	Paul Roman
Basic Research in Optoelectronics, Optics, and Laser Science at Berlin	10:574	Paul Roman
Physics and Microelectronics Research at the Institut Supérieur d'Electronique du Nord	10:578	Daniel J. Collins
Fiber-Optic Telemetry at the Electric Company of Portugal	10:598	Paul Roman
1st European Workshop on High T <sub>c</sub> Super- conductors and Potential Applications	87-01:50	Ray Kaplan
Quantum Optics Research at Naples University	87-01:54	Paul Roman
Topics Related to Nanometer Electronics--A Workshop Session Sponsored by ONRL	87-01:66	Paul Roman
A Small French Meeting on Optical Communications	87-02:54	Paul Roman

New International Advanced Multidis-		
ciplinary Theoretical Study-Institute		
Announced	87-02:63	Paul Roman
Structural Effects in Amorphous Ferromag-		
nets--An ONRL Supported Conference		
Session	87-02:63	Paul Roman
ONR-London has Sponsored a Conference		
Session on Unusual Applications of		
Advanced Molecular Spectroscopy	87-02:64	Paul Roman
An International Optics Exhibition in		
Madrid	87-02:65	Paul Roman

#### SCIENCE POLICY

The Technical Information Library at		
Hannover Keeps an Eye on the East	3:168	Paul Roman
National Research Centers in West Germany	4:212	Paul Roman
Italy Plans Big Strides in		
Optoelectronics R&D	6:341	Paul Roman
Progress in the UK Low-Dimensional		
Structures Initiative	7:407	Paul Roman
The Physics Committee of SERC Reviews		
Physics Activities in the United		
Kingdom	7:407	Paul Roman
The Launching of BRAIN in Europe	9:522	Paul Roman
European Ultraviolet Space Observatory	87-01:68	Paul Roman

#### SPACE SCIENCES

Open Window Detectors for Ultraviolet		
Astronomy--A Workshop Report	4:209	George R. Carruthers and Donald J. Michels
The Vatican Advanced Technology		
Telescope to be Located in Arizona	4:210	Muhammad Adel Miah
NATO Advanced Study Institute--Physical		
Processes in the Interstellar Medium	5:265	Philip R. Schwartz
X-Ray Sensor Lifted into Orbit in First		
Anglo-Japanese Space Venture	5:283	C.J. Fox
The Few-Body Problem--IAU Colloquium		
Number 96, Turku, Finland	10:582	Dale G. Bettis

### 1986-1987 SCIENCE NEWSBRIEFS

#### BIOLOGICAL SCIENCES

Call for Papers for International		
Conference on Bioreactors and		
Biotransformations	4-14	Claire E. Zomzely-Neurath
Spotlight on Biocommunication	4-16	Claire E. Zomzely-Neurath

#### CHEMISTRY

THERMOSALT: A THERMOSALT Databank of		
Molten Salt Mixtures	5-2	David L. Venezky
Second International Conference on		
Polymers in a Marine Environment		
Announced	4-12	David L. Venezky

#### MATERIAL SCIENCES

EUROSENSORS: Third Conference on Sensors		
and Their Applications	5-4	Louis Cartz
Levitation of Ceramic Spheres by		
Acoustic Waves for Studies at 6000 K		
by Laser Beam Heating	5-6	Louis Cartz
ONRL Workshop on Engineering Materials for		
Very High Temperatures	5-7	Louis Cartz
Acoustic Scavenging of the Open Air	5-9	Louis Cartz

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Meetings on: Polymer for Marine Environment (UK), 14-16 October 1987, Composites for Naval Construction (France) 16-18 March 1988	5-10	Louis Cartz
Polymer Science Meetings in Europe 1987-1988	5-11	Louis Cartz

#### MECHANICS

Seminars on Fluid Mechanics at the University of Cambridge, England	4-13	Eugene F. Brown
Seminars on Fluid Mechanics at the University of Cambridge, England	5-1	Eugene F. Brown
Fluid Mechanics Meetings in Europe 1987-1989	5-3	Eugene F. Brown
Fluid Mechanics Meeting in Europe and the Middle East	5-8	Eugene F. Brown

#### PHYSICS

Pioneering Results in Image Processing at British Aerospace	4-15	Paul Roman
Shortest Laser Pulse Record in the UK	5-13	Paul Roman

### 1987 ONRL REPORTS

ONR, London, reports are listed by subject, with title, report number, and author. Reports with the "C" discuss European and Middle Eastern conferences; the "R" suffix indicates reports that provide detailed examinations of research.

#### BEHAVIORAL SCIENCES

European Perspectives on Developmental Psychology: The 2nd European Conference on Developmental Psychology	7-006-C	William D. Crano
A Free-Response Method of Computer Personality Assessment: A Research Update	7-016-R	William D. Crano
An Assessment of the NATO Advanced Research Workshop on Environmental Psychology and Its Participants	7-018-C	William D. Crano
Proceedings--23rd International Military Psychology Symposium	7-033-C	William D. Crano

#### BIOLOGICAL SCIENCES

Biotechnica '86: 2nd International Congress for Biotechnology, Hannover, West Germany	7-001-C	Claire E. Zomzely-Neurath
Third European Seminar and Exhibition: Computer Aided Molecular Design, London, UK	7-007-C	Claire E. Zomzely-Neurath
Molecular Biology: Conference on Genetic Engineering Techniques	7-009-C	Claire E. Zomzely-Neurath
Biotechnology Conference: Protein Engineering '87, University of Oxford, UK	7-019-C	Claire E. Zomzely-Neurath
Biochemistry Conference: The Cytoskeleton in Cell Differentiation and Development	7-024-C	Claire E. Zomzely-Neurath
Biotechnology: Biointeractions '87, Cambridge, UK	7-032-C	Claire E. Zomzely-Neurath

#### COMPUTER SCIENCES

Research and Development at Centre Suisse d'Electronique et de Microélectronique (CSEM)	7-015-R	J.F. Blackburn
The British Technology Group	7-022-R	J.F. Blackburn

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MATERIALS SCIENCES

NATO Workshop on the Design, Activation and Transformation of Organometallics into Common and Exotic Material	7-005-C	Robert W. Vest
The 5th Europhysical Conference on Lattice Defects in Ionic Crystals	7-008-C	Robert W. Vest
Applied Material Sciences in Turkey	7-013-R	Louis Cartz
Metal Physics, Université De Poitiers, France	7-014-R	Louis Cartz
Ceramic-Ceramic Composites Meeting in Belgium	7-020-R	Louis Cartz
A Joint UK-West German Meeting Discusses Advanced Engineering Ceramics	7-029-C	Louis Cartz
Assessment of Electroceramic Research in Europe and the Middle East	7-028-R	Robert W. Vest
2nd NATO Workshop on Passive Infrared Optical Material and Coatings	7-031-R	Robert W. Schwartz

MECHANICS

Fluid Mechanics at the Middle East Technical University and the Istanbul Technical University	7-012-R	Eugene F. Brown
Facilities and Research at the French-German Institute of Research at Saint-Louis	7-017-R	Daniel J. Collins
International Conference on the Aerodynamics at Low Reynolds Numbers Between $10^4$ & $10^6$	7-023-C	Thomas J. Mueller
European Reacting Flow Research: A Final Assessment	7-027-R	Eugene F. Brown
AGARD--The NATO Advisory Group for Aerospace Research and Development	7-025-C	Dennis R. Sadowski
Highlights of the 70th Flight Mechanics Panel Symposium on flight Vehicle Development Time and Cost Reduction	7-026-C	Dennis R. Sadowski
International Conference on Industrial and Applied Mathematics	7-030-C	Eugene F. Brown

OCEAN SCIENCES

1986 Meeting of the Estuarine and Brackish Water Science Association	7-002-C	Jerome Williams
UK Oceanographers Meet in Southampton	7-003-C	Jerome Williams
1986 Conference on the Variability of the Atmosphere and Oceans	7-004-C	Jerome Williams
The International Symposium on Microwave Signatures and Remote Sensing	7-010-C	Jerome Williams

PHYSICS

German Quantum Optics Research in the Mirror of the Annual Physical Society Meeting	7-011-C	Paul Roman
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MULTIDISCIPLINE

Italy's Institute of Research on Electromagnetic Waves--Istituto Di Ricerca Sulle Onde Elettromagnet	7-021-R	Daniel J. Collins
LDA Measurements and Control Theory	7-034-R	Daniel J. Collins



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